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Report to Congressional Committees

April 2004

MISSILE DEFENSE

Actions Are Needed to Enhance Testing and Accountability

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Highlights

Highlights of GAO-04-409, a report to congressional committees

April 2004

MISSILE DEFENSE

Actions Are Needed to Enhance Testing and Accountability

Why GAO Did This Study

The Department of Defense (DOD) has treated ballistic missile defense as a priority since the mid-1980s and has invested tens of billions of dollars to research and develop such capabilities. In 2002 two key events transformed DOD's approach in this area: (1) the Secretary of Defense consolidated existing missile defense elements into a single acquisition program and placed them under the management of the Missile Defense Agency (MDA) and (2) the President directed MDA to begin fielding an initial configuration, or block, of missile defense capabilities in 2004. MDA estimates it will need $53 billion between fiscal years 2004 and 2009 to continue the development, fielding, and evolution of ballistic missile defenses.

To fulfill a congressional mandate, GAO assessed the extent to which MDA achieved program goals in fiscal year 2003. While conducting this review, GAO also observed shortcomings in how MDA defines its goals.

What GAO Recommends

GAO recommends that DOD carry out independent, operationally realistic testing of each block being fielded. GAO also recommends that MDA set cost, schedule, and performance baselines for each block being fielded. DOD agreed to establish these baselines but stated that formal operational testing is not required before entry into full-rate production.

www.gao.gov/cgi-bin/getrpt?GAO-04-409.

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.

What GAO Found

MDA accomplished many activities in fiscal year 2003—such as software development, ground and flight testing, and the construction of facilities at Fort Greely, Alaska—leading up to the fielding of the initial block of the Ballistic Missile Defense System. During this time, however, MDA experienced schedule delays and testing setbacks, resulting in the fielding of fewer components than planned in the 2004-2005 time frame. For example, delays in interceptor development and delivery have caused flight tests (intercept attempts) of the Ground-based Midcourse Defense (GMD) element to slip over 10 months. In flight tests conducted during fiscal year 2003, MDA achieved a 50 percent success rate in intercepting target missiles. While MDA is increasing the operational realism of its developmental flight tests—e.g., employing an operational crew during its late 2003 ship-based intercept attempt—the GMD element has not been tested under unscripted, operationally realistic conditions. Therefore, MDA faces the challenge of demonstrating whether the capabilities being fielded, consisting primarily of the GMD element, will perform as intended when the system becomes operational in 2004. Finally, MDA's cost performance during fiscal year 2003 was mixed. The prime contractors of four system elements completed work at or near budgeted costs during this time, but prime contractors for two system elements overran budgeted costs by a total of about $380 million.

GAO found that program goals do not serve as a reliable and complete baseline for accountability purposes and investment decision making because they can vary year to year, do not include all costs, and are based on assumptions about performance not explicitly stated. For example, between its budget requests for fiscal years 2004 and 2005, MDA revised its estimated cost for the first fielded block of missile defense capability. This first block is costing $1.12 billion more and consists of fewer fielded components than that planned a year earlier. In addition, MDA's acquisition reports for Congress do not include life-cycle costs, which normally provide explicit estimates for inventory procurement, military construction, operations, and maintenance. Finally, MDA does not explain some critical assumptions—such as an enemy's type and number of decoys—underlying its performance goals. As a result, decision makers in DOD and Congress do not have a full understanding of the overall cost of developing and fielding the Ballistic Missile Defense System and what the system's true capabilities will be.

Elements of MDA's 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
	Theater High Altitude Area Defense

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

Contents

Tables

Figures

Abbreviations

ABL	Airborne Laser
Aegis BMD	Aegis Ballistic Missile Defense
AFB	Air Force Base
ALI	Aegis LEAP Intercept
ARS	Active Ranger System
BC/FC	Beam Control/Fire Control
BILL	Beacon Illuminator Laser
BMC2	Battle Management, Command and Control
BMDS	Ballistic Missile Defense System
BV	Booster Validation
C2BMC	Command, Control, Battle Management, and Communications

CDR	Critical Design Review
COIL	Chemical Oxygen-Iodine Laser
CONOPS	Concept of Operations
CONUS	Continental United States
CSD	Chemical Systems Division
CTF	Control Test Flight
DACS	Divert and Attitude Control System
DOD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
DRR	Design Readiness Review
EKV	Exoatmospheric Kill Vehicle
EMD	Engineering and Manufacturing Development
EVMS	Earned Value Management System
FM	Flight Mission
FT	Flight Test
FY	Fiscal Year
GAO	General Accounting Office
GBI	Ground Based Interceptor
GMD	Ground-based Midcourse Defense
ICBM	Intercontinental Ballistic Missile
IDO	Initial Defensive Operations
IFICS	In-Flight Interceptor Communications System
IFT	Integrated Flight Test
IMP	Integrated Master Plan
IMS	Integrated Master Schedule
IOC	Initial Operational Capability
JNIC	Joint National Integration Center
KEI	Kinetic Energy Interceptors
LEAP	Lightweight Exoatmospheric Projectile
LRIP	Low-Rate Initial Production
MDA	Missile Defense Agency
MDNT	Missile Defense National Team
NFIRE	Near Field Infrared Experiment
NMD	National Missile Defense
OSC	Orbital Sciences Corporation
OTA	Other Transaction Agreement
PD&RR	Program Definition and Risk Reduction
PDR	Preliminary Design Review
PMRF	Pacific Missile Range Facility
POET	Phase One Engineering Team
RDT&E	Research, Development, Testing, and Evaluation
SAR	Selected Acquisition Report

SBIRS	Space-Based Infrared System
SBX	Sea-Based X-band Radar
SCF	Seeker Characterization Flight
SDACS	Solid Divert and Attitude Control System
SDD	System Development and Demonstration
SIL	System Integration Laboratory
SM	Standard Missile
STSS	Space Tracking and Surveillance System
TILL	Target Illuminator Laser
THAAD	Theater High Altitude Area Defense
TPM	Technical Performance Measure
USNORTHCOM	U.S. Northern Command
USPACOM	U.S. Pacific Command
USSTRATCOM	U.S. Strategic Command
WSMR	White Sands Missile Range

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Congressional Committees

The Department of Defense (DOD) has been making significant investments in the development of ballistic missile defenses for decades. From 1985, when the Strategic Defense Initiative was launched, through 2003, DOD spent tens of billions of dollars to research and develop these capabilities. It estimates that it will need $53 billion between fiscal years 2004 and 2009 to continue the development, fielding, and evolution of ballistic missile defenses.

During the past 2 years, DOD significantly transformed the approach it takes in acquiring ballistic missile defenses. In January 2002, the Secretary of Defense refocused the ballistic missile defense program into a broad-based research and development effort managed by the Missile Defense Agency (MDA). The Secretary granted MDA flexibility to employ a "capability-based," evolutionary approach for the development of these defenses. Under this new approach, MDA defines, develops, and fields operational capabilities—in 2-year blocks—of a single, multilayered, overarching system referred to as the Ballistic Missile Defense System (BMDS). The system has no fixed design or final architecture. The Secretary of Defense also gave MDA management responsibility over the existing ballistic missile defense programs already under development by the military services. These programs, which were previously recognized by DOD as major defense acquisition programs, are now considered "elements" of the BMDS. (See table 1 for a description of BMDS elements under development.)

In December 2002, the President directed DOD to begin fielding an initial set of missile defense capabilities in 2004. In accordance with the President's direction, MDA is readying a defensive capability for operation, called Initial Defensive Operations (IDO), by September 30, 2004. IDO is expected to provide the United States protection against limited long-range ballistic missile attacks from Northeast Asia. MDA will enhance this capability to complete the first increment of the BMDS—known as the Block 2004 defensive capability—by the end of December 2005. This capability is expected to provide additional protection from ballistic missiles launched from the Middle East.

The *National Defense Authorization Act for Fiscal Year 2002*[1] directed DOD to establish schedule, testing, performance, and cost goals for its ballistic missile defense programs for the years covered by the Future Years Defense Plan.[2] 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.[3] Because the agency had not established goals in fiscal year 2002, we were unable to assess its progress for that year.[4] However, MDA did establish schedule, testing, performance, and cost goals for its Block 2004 program and submitted them to Congress in February 2003 with its fiscal year 2004 budget and in April 2003 with its Selected Acquisition Report for the BMDS.[5] The goals describe the composition of the block configuration under development; provide the costs and schedule associated with developing, testing, and fielding the Block 2004 BMDS; and summarize the performance capabilities that MDA expects to achieve with the Block 2004 defensive capability.

To fulfill the congressional mandate in the Authorization Act, we addressed the following question in this report: To what extent has MDA and its elements progressed in achieving stated goals through their fiscal year 2003 activities? While conducting this review, we observed shortcomings in how MDA defines its Block 2004 program goals. Our report includes these observations and our recommendations for improvement.

Scope and Methodology

We assessed MDA's progress made during fiscal year 2003 toward its Block 2004 program goals by reviewing the progress of individual BMDS elements, because MDA program goals are ultimately derived from element-level efforts. We selected seven elements for our review on the

[1] Pub. L. No. 107-107, § 232(c), 10 U.S.C. § 2431 note (Supp. I 2001).

[2] The Future Years Defense Plan is DOD's official document for summarizing the forces and resources (budget) associated with programs approved by the Secretary of Defense. The current Future Years Defense Plan covers fiscal years 2004-2009.

[3] Pub. L. No. 107-107, § 232(g), 10 U.S.C. § 2431 note (Supp. I 2001).

[4] See appendix IX for a discussion of MDA's tools for monitoring cost, schedule, and performance progress in 2002.

[5] Required by 10 U.S.C. § 2432 (2000 & Supp. I 2001), Selected Acquisition Reports are submitted regularly for updating the Congress on a weapon system's cost and developmental progress.

basis of congressional interest and because they account for about 70 to 75 percent of the cumulative research and development funds MDA budgeted for fiscal years 2002 through 2009. We compared each element's actual cost, completed activities, demonstrated performance, and test results with their internal fiscal year 2003 cost, schedule, performance, and testing goals.

To assess progress toward program schedule goals, we examined, for each element, prime contractor Cost Performance Reports, the Defense Contract Management Agency's analyses of these reports, System Element Reviews, and other agency documents to determine whether key activities scheduled for the fiscal year were accomplished as planned. We also developed a data collection instrument to gather additional, detailed information on completed program activities, including tests, design reviews, prime contracts, and estimates of element performance.

Because MDA allocates a large percentage of its budget to fund prime contractors that develop system elements, and because MDA's cost goal did not apply to fiscal year 2003 expenditures, we limited our review of cost-related matters to assessments of prime contractor cost performance. To make these assessments, we applied earned value analysis techniques to data captured in contractor Cost Performance Reports. We compared the cost of work completed with the budgeted costs for scheduled work for the fiscal year 2003 period. Results were presented in graphical form to determine fiscal year 2003 trends. We also used data from the reports to project the likely costs at the completion of prime contracts through established earned value formulas.

We also analyzed data related to system effectiveness provided by MDA, focusing on the Ground-based Midcourse Defense and Aegis Ballistic Missile Defense elements—the weapon components of 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 within DOD's office of the Director, Operational Test and Evaluation, to learn more about the adequacy of element test programs and the operational capability demonstrated by them to date.

As we reviewed documents and held discussions with agency officials, we looked for evidence of key cost, schedule, and technical risks. We identified key risks as those for which we found evidence of problems or significant uncertainties that could negatively affect MDA's ability to develop, demonstrate, and field a militarily useful capability within schedule and cost estimates.

During our review, we observed shortcomings in how MDA defines its goals that could make oversight by external decision makers more difficult. To pursue this matter, we examined how MDA reported its goals by reviewing MDA budget submission statements that were submitted for fiscal years 2004 and 2005. In addition, to gain insight into the formulation of the goals, we held numerous discussions with MDA officials and reviewed acquisition documents such as MDA's Integrated Master Plan, Integrated Program Plan, and System Integration Strategy.

Our work was primarily performed at MDA headquarters, Arlington, Virginia; Aegis Ballistic Missile Defense Program Office, Arlington, Virginia; Airborne Laser Program Office, Albuquerque, New Mexico; Command, Control, Battle Management, and Communications Program Office, Arlington, Virginia; Ground-based Midcourse Defense Program Office, Arlington, Virginia; Kinetic Energy Interceptors Program Office, Arlington, Virginia; Space Tracking and Surveillance System Program Office, Los Angeles, California; and the Theater High Altitude Area Defense Project Office, Huntsville, Alabama. We also visited the office of the Director, Operational Test and Evaluation, Arlington, Virginia.

We conducted our review from June 2003 through April 2004 in accordance with generally accepted government auditing standards.

Results in Brief

MDA completed many activities in fiscal year 2003—such as software development, ground and flight testing, and facility construction at various BMDS sites—leading to the planned initial fielding of the BMDS by September 2004. During this time, however, MDA experienced significant schedule delays, conducted little testing of the integrated BMDS, and incurred cost overruns. Also, as a result of testing shortfalls, the predicted effectiveness of the Block 2004 system will be largely unproven. Furthermore, between its budget requests for fiscal years 2004 and 2005, MDA revised the goals for its first fielded block of missile defense capability by increasing costs by $1.12 billion and decreasing the number of fielded components.

Our overall assessment of MDA's progress in fiscal year 2003 toward meeting its schedule, testing, performance, and cost goals is discussed below. Key risks associated with the development and fielding of system elements are summarized as well.

- **Schedule and testing**. Primary system elements that make up the fielded Block 2004 defensive capability—Ground-based Midcourse Defense (GMD) and Aegis Ballistic Missile Defense (BMD)—are executing aggressive schedules to meet the fielding dates prescribed under the President's directive. These elements completed a number of activities that MDA expects will lead to the achievement of its program goals. For example, construction activities for facilities at Fort Greely, Alaska, and other GMD sites were completed on or ahead of schedule. However, based on progress made in fiscal year 2003, the actual defensive system to be fielded by September 2004 will have fewer components than planned. For example, we found that MDA will not meet its upper-end goal of fielding 10 GMD interceptors by September 2004. In addition, the agency will be hard-pressed to achieve its goal of producing and delivering an inventory of 20 GMD interceptors by December 2005, because GMD contractors have yet to meet the planned production rate.

  MDA completed many activities toward the completion of the BMDS Test Bed, the venue in which system elements are integrated and tested. However, some element-level testing did not progress as planned. During fiscal year 2003, MDA achieved a 50-percent success rate on hit-to-kill intercepts—one success out of two attempts for each of the GMD and Aegis BMD elements. Also during this time period, delays in GMD interceptor development and delivery caused flight tests (intercept attempts) leading up to IDO to slip 10 months or more. Furthermore, unanticipated problems in system-integration efforts caused key Airborne Laser (ABL) demonstration events to slip over a year.

- **Performance**. MDA predicts with confidence that the September 2004 defensive capability will provide protection of the United States against limited attacks from Northeast Asia. However, testing in 2003 did little to demonstrate the predicted effectiveness of the system's capability to defeat ballistic missiles as an integrated system. None of the components of the defensive capability have yet to be flight tested in their fielded configuration (i.e., using production-representative hardware).

- **Cost**. We assessed prime contractor cost performance for six BMDS elements funded under the Block 2004 program. Four of the six elements completed fiscal year 2003 work at or near budgeted costs. However, work on ABL and GMD cost much more than budgeted. The ABL contractor overran budgeted costs by $242 million and the GMD contractor by $138 million.

- **Key risks**. Our analysis of fiscal year 2003 activities indicates there are key risks associated with the development and fielding of elements of the Block 2004 program. For example, significant uncertainty remains about how much more time and money are required to complete ABL integration activities and whether ABL can be proven to work effectively. MDA recently announced that a new contract structure is being implemented to more efficiently demonstrate the technology.

Also, as a result of testing shortfalls and the limited time available to test the BMDS being fielded, system effectiveness will be largely unproven when the initial capability goes on alert at the end of September 2004. Delays in flight testing presented MDA with limited opportunities to demonstrate the operation of hardware and software being fielded and to resolve any problems that may be uncovered during flight testing before September 2004. In addition, although MDA is attempting to make flight tests as realistic as possible, these tests will not be conducted under the unscripted conditions that characterize operational testing. Independent, operational testing through an operational test agent outside of the program being developed, and through the input of DOD's independent operational test and evaluation office, is intended to demonstrate objectively how capable a system truly is and whether the warfighter can trust it to be suitable and effective.

During our review, we observed shortcomings in how MDA defines its Block 2004 program goals. As discussed below, program goals do not serve as a reliable and complete baseline for oversight and investment decision-making because they can vary year-to-year, do not include life-cycle costs, and are based on assumptions about performance not explicitly stated.

- **Variable program goals**. MDA's methodology for establishing program goals—both cost and block content—allows for variations from one year to the next. MDA recognized that the first BMDS block will cost more and deliver fewer fielded components than originally planned. As reported in DOD budget submissions for fiscal years 2004 and 2005, the Block 2004 cost goal increased from $6.24 billion to $7.36 billion, the Aegis BMD interceptor inventory decreased from 20 to 9, the number of Aegis BMD ships upgraded for the long-range surveillance and tracking mission decreased from 15 to 10, and the potential operational use of ABL and the sea-based radar[6] as sensors is no longer part of Block 2004. The variability weakens accountability because the goals cannot serve as a reliable baseline for measuring cost, schedule, and performance status over time.

- **Reporting life-cycle costs**. DOD categorizes the BMDS as a Research, Development, Testing, and Evaluation (RDT&E)-only program costing $53 billion between fiscal years 2004 and 2009. Accordingly, the BMDS Selected Acquisition Report does not specify costs for procurement, military construction, and operations and maintenance that are part of a full life-cycle cost estimate. Given the imminent fielding of a missile defense capability, procurement of inventory, and funding of operation and sustainment costs, this Selected Acquisition Report provides an incomplete cost picture to decision makers in DOD and Congress. MDA officials told us that they are working to include life-cycle cost estimates in future Selected Acquisition Reports for the BMDS.

- **Assumptions about performance**. BMDS performance goals, such as the probability of engagement success, are based on assumptions regarding the system's capability against certain threats under various engagement conditions. Neither the engagement conditions nor critical assumptions about the threat—such as the enemy's type and number of decoys—used in establishing these goals are explicitly stated as part of MDA's program goals. Without these implicit assumptions being explained, the operational capability of the fielded system is difficult to fully understand.

[6] An X-band radar emplaced on a sea-based, mobile platform in the Pacific will be used in flight testing or as an operational asset for tracking enemy warheads and discriminating warheads from decoys.

To more independently test the BMDS and give the warfighter greater confidence that the system will perform as intended, we are recommending that independent, operationally realistic testing and evaluation be conducted for each BMDS block configuration being fielded. Also, to enhance accountability and the ability of decision makers in Congress and DOD to provide oversight, we are recommending that cost, schedule, and performance baselines, including full life-cycle costs, be established for each block configuration being fielded and that year-to-year variations in baselines be explained. DOD concurred with our recommendations regarding cost, schedule, and performance baselines but non-concurred with our recommendations for operational testing.

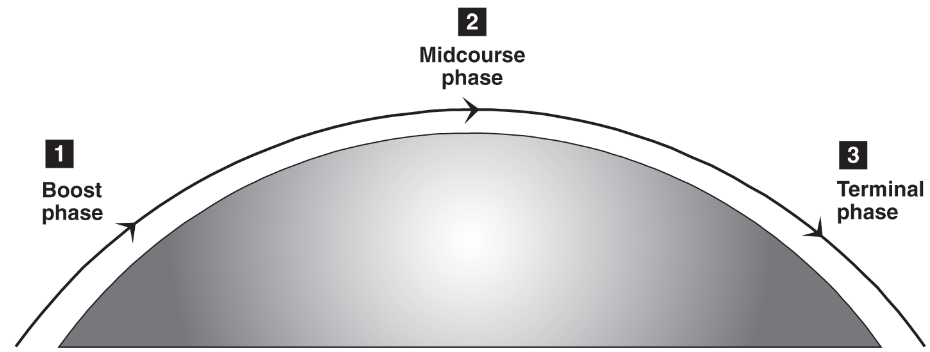
In commenting on the draft report, DOD stated that there is no statutory requirement to conduct operational testing of developmental items and that it will conduct formal operational test and evaluation when an element of the BMDS matures and transitions from MDA to a military service and before entry into full-rate production. We retain our recommendation that DOD conduct independent, operational testing of block configurations being fielded. Given that inventory is being procured and the system is being fielded, decision makers considering further investments in the system should have an independent, objective assessment of whether the fielded system can be trusted to perform as intended.

Background

MDA has the mission to develop and field a Ballistic Missile Defense System capable of defeating ballistic missiles of all ranges in all phases of flight. In particular, the system is intended to defend the U.S. homeland against intercontinental ballistic missile (ICBM)[7] attacks and to protect deployed U.S. armed forces, which are operating in or near hostile territories, against short- and medium-range ballistic missiles. Additionally, the BMDS is to evolve into a system that is capable of defending friends and allies of the United States. Figure 1 depicts the three phases of a missile's flight during which the BMDS is designed to engage it.

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

Figure 1: Phases of a Ballistic Missile's Trajectory



Boost phase is the first phase of a ballistic missile's trajectory, during which a missile's rocket motors are thrusting. This phase typically lasts 3-5 minutes for intercontinental ballistic missiles.

Midcourse phase is the phase after which the missile has stopped thrusting and the deployed warhead and associated objects (e.g., decoys) travel through space on a predictable path. This phase can last 20 minutes for intercontinental ballistic missiles and provides the largest window of opportunity for intercepting the enemy missile.

Terminal phase is the final phase of a ballistic missile's trajectory, lasting about a minute or less. This is when the warhead reenters the atmosphere. To defend against a ballistic missile attack during this phase, the defensive capability must be positioned close to the warhead's intended target.

Source: MDA.

Much of the operational capability of the Block 2004 BMDS results from capabilities developed in legacy programs. These include the GMD, Aegis BMD, and Patriot elements. Existing space-based sensors would also be available, including Defense Support Program satellites, for the early warning of missile launches. The Block 2004 BMDS can be viewed as a collection of semi-autonomous missile defense systems interconnected and coordinated through the Command, Control, Battle Management, and Communications (C2BMC) element. Functional pieces of system elements, such as radars or interceptors, are referred to as "components."

Block 2004 program goals involve developmental activities of five MDA elements: Aegis BMD, ABL, C2BMC, GMD, and Theater High Altitude Area Defense (THAAD).[8] As indicated above, three of these five elements—GMD, Aegis BMD, and C2BMC—comprise the Block 2004 defensive

[8] MDA recently changed the name of the THAAD element to "Terminal High Altitude Area Defense."

capability that is currently being fielded. MDA is also funding the development of two other elements—Space Tracking and Surveillance System (STSS) and Kinetic Energy Interceptors (KEI)—but these elements are part of future blocks of the MDA missile defense program.

Table 1 provides a brief description of these seven elements.[9] More complete descriptions of these elements are provided in the appendixes of this report.

Table 1: BMDS Elements

Element	Missile defense role
Aegis Ballistic Missile Defense	A ship-based element designed to destroy short- and medium-range ballistic missiles during the midcourse phase of flight. The element's mission is to defend deployed U.S. forces and to perform early tracking of long-range ballistic missiles in support of the GMD mission. It is planned to be operational in Block 2004.
Airborne Laser	An air-based element designed to destroy all classes of ballistic missiles during the boost phase of flight.
Command, Control, Battle Management, and Communications	MDA plans to make this the integrating and controlling element of the BMDS. It is planned to be operational in Block 2004.
Ground-based Midcourse Defense	A ground-based element designed to destroy long-range ballistic missiles during the midcourse phase of flight. Its mission is to defend the U.S. homeland when it becomes operational in Block 2004.
Kinetic Energy Interceptors	A land-based element designed to destroy long-range ballistic missiles during the boost and ascent phases of flight. Its capability is expected to be available in Block 2010.
Space Tracking and Surveillance System	Envisioned as a constellation of satellites for missile warning and tracking, STSS satellites are intended to support the missile defense mission. Any real operational capability of next-generation satellites will not be available until the next decade.

[9] Our review focused on only those elements managed by MDA. Patriot PAC-3, which is funded and managed by the Army, is part of the BMDS for terminal (point) defense against short- and medium-range ballistic missile attacks.

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Element	Missile defense role
Theater High Altitude Area Defense	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. It is planned to be operational in Block 2008.

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

During Block 2006, MDA will focus on fielding additional hardware and enhancing the performance of the BMDS. For example, MDA plans to field additional GMD interceptors at Fort Greely, add new radars that can be deployed overseas, and incorporate enhanced battle management capabilities into the C2BMC element.

For Blocks 2008 and 2010, MDA plans to augment the Block 2006 capability with boost phase capabilities being developed in the ABL and KEI programs. Additionally, MDA plans to field the THAAD element for protecting deployed U.S. forces against short- and medium-range ballistic missiles.

According to MDA officials, the integrated BMDS offers more than simply the deployment of individual, autonomous elements. A synergy results from information sharing and enhanced command and control, yielding a layered defense with multiple shot opportunities. This preserves interceptor inventory and increases the opportunities to engage ballistic missiles.

MDA Block 2004 Program Goals

MDA developed overarching goals for the development and fielding of the Block 2004 BMDS.[10] The goals describe the composition of Block 2004; provide the costs and schedule associated with its development, testing, and fielding; and summarize its performance capabilities. As part of MDA's *Statement of Goals*, MDA also identified and scheduled a number of events that must be completed by individual program elements in 2004 and 2005 if the goals are to be achieved.

[10] MDA goals are formally detailed in the agency's budget estimates and in the top-level MDA document, *Block 2004 Statement of Goals*.

At the core of MDA's Block 2004 program goals is the continued development and testing of ABL, Aegis BMD, C2BMC, GMD, and THAAD. These goals are referred to as "Block 2004 Development Goals" and identify the developmental areas MDA is funding during the Block 2004 time frame, that is, during calendar years 2004 and 2005. MDA also established a complementary set of goals—referred to as Block 2004 "Operational Alert Configuration" Goals[11]—in response to the President's December 2002 direction to begin fielding a ballistic missile defense capability. These fielding goals build directly upon the development goals and identify the operational missile defense capability that MDA expects to deliver by the end of December 2005.

The Block 2004 cost goal covers budgeted costs for development and fielding during calendar years 2004-2005. When MDA submitted its fiscal year 2004 budget in February 2003, MDA declared that its Block 2004 cost goal was $6.24 billion. However, MDA recently revised its Block 2004 cost goal with the submission of its fiscal year 2005 budget in February 2004. The revision reflects updated developmental costs and an update to the additional costs associated with the initial fielding. MDA's Block 2004 cost goal is now $7.36 billion.

The missile defense capability of Block 2004 is primarily one for defending the United States against long-range ballistic missile attacks. As summarized in table 2, it is built around the GMD element, augmented by Aegis BMD radars, and integrated by the C2BMC element. The Block 2004 BMDS also contains the Patriot PAC-3 element for point defense of deployed U.S. armed forces against short- and medium-range ballistic missiles. Because MDA no longer has funding or management responsibility over Patriot, an assessment of progress made by the Army in fiscal year 2003 toward delivering the listed capability was not addressed in this review. Patriot-specific goals are, therefore, not listed in the table.

[11] In budget documentation submitted in February 2003, MDA referred to these goals as Block 2004 "Initial Defensive Capability" Goals.

Table 2: MDA Block 2004 Defensive Capability Goals

BMDS element	IDO[a] (Sept. 30, 2004)	Block 2004 (Dec. 31, 2005)	Functionality
GMD	• Up to 10 interceptors • Upgraded Cobra Dane radar • 1 upgraded early warning radar • Fire control nodes	• 20 interceptors • Upgraded Cobra Dane radar • 2 upgraded early warning radars • Fire control nodes	Defend the U.S. homeland against ICBM attacks
Aegis BMD	• 5 missiles[b] • 3 Aegis destroyers (long-range surveillance and tracking only) • 1 Aegis cruiser	• 9 missiles • 10 Aegis destroyers (long-range surveillance & tracking only) • 3 Aegis cruisers	Sea-based defense against short- and medium-range ballistic missiles; early tracking of ICBMs to support the GMD mission
C2BMC	• 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	Integrating and controlling element of the BMDS

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

[a]Defensive capability goals associated with IDO are not formally documented. The goals listed were derived from element-level documents and from discussions with MDA officials.

[b]An intercept capability by Aegis BMD is not part of the September 2004 IDO.

Assessment of Progress and Key Risks

In this section, we summarize our assessment of MDA's progress in fiscal year 2003 toward achieving Block 2004 program goals. Key risks associated with developing and fielding system elements are summarized, as well. Detailed evaluations of element progress and risks are given in the appendixes of this report.

Schedule and Testing Assessment: Many Activities Completed, but Slips Have Occurred

MDA identified a number of events that must be completed to meet Block 2004 program goals. These activities, which are part of MDA's program goals, are ultimately derived from element-level efforts and, in general, have completion dates in calendar years 2004 or 2005 to coincide with the start of defensive operations. Progress made toward achieving Block 2004 goals, relative to these defining events, is summarized in tables 3 through 6.

Table 3: BMDS-wide Block 2004 Program Goals

Event	Progress assessment
Establish Block 2004 BMDS Configuration Required date: 2Q FY 2003[a]	As part of its block planning process, MDA defines the BMDS capabilities that can be realistically promised for delivery within the established block schedule and budget. The design of block capabilities follows an iterative approach under which a number of possible block alternatives—candidate BMDS capabilities that satisfy specific objectives and goals—are developed and assessed. This event was accomplished in fiscal year 2003 with the delivery of the “Block 2004 Configuration Definition” and Version 1.6 of the Block 2004 architecture.
Stand up Block 2004 BMDS Test Bed Expected date: 4Q FY 2004	MDA made significant progress toward the completion of the BMDS Test Bed, the venue in which system elements are integrated and tested. Many of the GMD activities completed in fiscal year 2003 for the development of the operational BMDS also pertain to the construction of Test Bed infrastructure at various GMD sites. The largest construction effort is at Fort Greely, where missile silos and supporting facilities are being built. All construction activities for Block 2004 are on, or ahead of, schedule.
Complete verification testing Expected date: 4Q FY 2005	MDA intends to verify that all elements and components of the Block 2004 architecture have been sufficiently tested. Although GMD and Aegis BMD each conducted two flight tests during fiscal year 2003—each achieved one intercept out of two attempts—element-level testing did not progress as planned. GMD flight tests (intercept attempts) leading up to IDO have slipped 10 months, largely a consequence of delays in interceptor development and delivery. Accordingly, the test schedule leading up to the September 2004 IDO has been severely compressed, limiting MDA’s opportunity to characterize GMD’s performance prior to the initial fielding.

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

Note: FY = fiscal year.

[a]We use the notation “2Q FY 2003” to mean the second quarter of fiscal year 2003 and an identical format for other time periods.

Table 4: GMD-Related Block 2004 Program Goals

Event	Progress assessment
Complete 1st Ground Based Interceptor (GBI) installation in Alaska and California Expected date: 4Q FY 2004	The GMD program had been working to deliver and install up to 10 interceptors at Fort. Greely, Alaska, and Vandenberg Air Force Base, California, for the September 2004 defensive capability. Many site preparation activities have been accomplished, including the construction of facilities and interceptor silos at Fort Greely. However, as highlighted in the GMD appendix, we found that MDA will not be able to field its upper-end goal of 10 GMD interceptors by September 2004. Rather, MDA expects to field 5 interceptors by September 2004 and complete the goal of 10 interceptors by February 2005.
Complete 2nd GBI installation in Alaska Expected Date: 4Q FY 2005	The GMD program aims to increase its inventory of interceptors for the Block 2004 defensive capability to 20 by December 2005. The production and delivery of all 20 interceptors by the end of Block 2004 is uncertain—GMD contractors have not demonstrated they can meet the increased production rate. In particular, the production rate for the GMD kill vehicle must increase by 50 percent.
Complete upgrade of early warning radars Expected date: 4Q FY 2005	The GMD program is upgrading two early warning radars—one at Beale Air Force Base, California, and another at Fylingdales Airbase in England—to enable the radars to more accurately track launched missiles for the planning of intercept engagements. The upgrades consist of hardware and software improvements. The completion of the Beale upgrade is on track for meeting the September 2004 IDO date. MDA has not yet begun upgrading the early warning radar at Fylingdales.
Complete sea-based X-band (SBX) radar Expected date: 1Q FY 2006	The GMD program office is managing the development of a sea-based X-band radar to be first tested by the end of Block 2004. During fiscal year 2003, MDA initiated the acquisition of SBX components, including its sea-based platform. MDA program officials stated that the SBX will be fielded as a test asset at the end of Block 2004 (December 2005), and budget documentation indicates that it will be placed on alert as an operational asset during Block 2006.

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

Table 5: Aegis BMD-Related Block 2004 Program Goals

Event	Progress assessment
Complete surveillance and tracking upgrade of up to 9 Aegis BMD destroyers Expected date: 3Q FY 2004	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. By September 2004, MDA expects to have upgraded three destroyers for this role rather than its goal of 9. Aegis destroyers for this role have been identified and are scheduled for modification.
Complete upgrade of up to 6 additional Aegis BMD destroyers Expected date: Block 2006	The Aegis BMD program had been working to complete the upgrade of a total of 15 Aegis destroyers by December 2005 to provide surveillance and early tracking of long-range ballistic missiles in support of the GMD mission. Aegis destroyers for this role have been identified and are scheduled for modification. However, MDA has altered this goal and now plans to upgrade a total of 10 destroyers during Block 2004 and the remaining 5 during Block 2006.
Deliver up to 20 Standard Missile (SM)-3 missiles Expected date: 4Q FY 2005	MDA had plans to deliver and install up to 20 Aegis BMD missiles—the SM-3—on Navy cruisers by December 2005. Although MDA completed an associated design review and initiated planning for production, it altered this goal and now plans to field 9 missiles.
Complete upgrade of 3 Aegis BMD cruisers with engagement capability Expected date: 4Q FY 2005	MDA is planning to field three Aegis cruisers, with an inventory of SM-3 missiles, for defense against short- and medium-range ballistic missiles. This requires physical modification to the ships as well as software upgrades for the engagement role. Aegis cruisers for this role have been identified and are scheduled for modification.

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

Table 6: C2BMC-Related Block 2004 Program Goals

Event	Progress assessment
Complete C2BMC operational suites Expected date: 4Q FY2005	The C2BMC program faces a tight schedule to get the BMDS on alert by the end of September 2004 for IDO. Our analysis shows, however, that it is on track for delivering the software build planned for this capability. The program also is continuing with integration activities and is completing activities needed to make the BMDS operational.

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

Performance Assessment: Effectiveness of System's Operational Capability Remains Largely Unproven

MDA reports that performance indicators associated with Block 2004 elements are generally on track for meeting expectations. This methodology leads MDA to predict with confidence that the September 2004 defensive capability will provide full coverage of the United States against limited attacks from Northeast Asia.

However, testing in 2003 did little to demonstrate the predicted effectiveness of the system's capability, as an integrated system, to defeat ballistic missiles. Without sufficient test data to anchor MDA's analyses, models, and simulations, the predicted effectiveness of the system will remain largely unproven when IDO is available in September 2004. As discussed below, the uncertainty stems from a lack of system-level testing—using production-representative hardware under operationally realistic conditions—of the Aegis BMD and GMD elements and the highly scripted nature of developmental tests to date.

The GMD program, which comprises the largest portion of the Block 2004 defensive capability, has demonstrated the capability to intercept target warheads in flight tests over the past 5 years. In fact, the program has achieved five successful intercepts out of eight attempts. However, because of range limitations, these flight tests were developmental in nature and, accordingly, engagement conditions were repetitive and scripted. Furthermore, as noted in our recent reports on missile defense, none of GMD's components of the defensive capability have been flight tested in their fielded configuration (i.e., with production-representative hardware).[12] For example, the GMD interceptor—booster and kill vehicle—will not be tested in its Block 2004 configuration until the next intercept attempt, which the GMD program office plans to conduct in the fourth quarter of fiscal year 2004. This intercept attempt will also test, for the first time, battle management software that will be part of the September 2004 defensive capability. Finally, MDA does not plan to demonstrate the operation of the critical GMD radar, called Cobra Dane, in flight tests before fielding IDO.

[12] U.S. General Accounting Office, *Missile Defense: Actions Being Taken to Address Testing Recommendations but Updated Assessment Needed*, GAO-04-254 (Washington, D.C.: Feb. 26, 2004); U.S. General Accounting Office, *Missile Defense: Additional Knowledge Needed in Developing System for Intercepting Long-Range Missiles*, GAO-03-600 (Washington, D.C.: Aug. 21, 2003).

Similarly, the Aegis BMD program has demonstrated the capability to intercept a non-separating target through its successes in four out of five attempts. These successes are noteworthy, given the difficulty of achieving hit-to-kill intercepts. In his fiscal year 2002 report, DOD's Director, Operational Test and Evaluation (DOT&E)[13] noted the successes but pointed out that the flight tests were developmental in nature and neither operationally realistic nor intended to be so. Test scenarios and target "presentation"[14] were simple compared with those expected to be encountered during an operational engagement. While MDA is increasing the operational realism of its developmental flight tests—e.g., the Aegis Ballistic Missile Defense element employed an operational crew during its December 2003 intercept attempt—tests completed to date are highly scripted.

Cost Assessment: Prime Contractor Fiscal Year 2003 Performance Mixed

We used contractor Cost Performance Reports to assess the prime contractors' progress toward MDA's cost and schedule goals during fiscal year 2003. 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—activities costing less or completed ahead of schedule—are generally considered as good news and negative variances—activities costing more or falling behind schedule—as bad news. We addressed cost performance at the element level because the agency does not generate a single, overarching cost performance report for its contracts. Our detailed findings are presented in the element appendixes of the report.

As shown in table 7, the Aegis BMD, C2BMC, STSS, and THAAD prime contractors performed work in fiscal year 2003 at or near budgeted costs. However, work completed in the ABL and GMD programs cost more than budgeted. The ABL prime contractor overran its budgeted cost by

[13] 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.

[14] The target flew a trajectory so that it presented a large cross section to the radar.

approximately $242 million, and the GMD prime contractor's work cost about $138 million more than expected.

Table 7: Prime Contractor Cost and Schedule Performance in Fiscal Year 2003

Dollars in millions

BMDS element	Cost variance	Schedule variance[a]	Comments
ABL	(242)	(28)	The underestimated complexity of integrating ABL subcomponents into a flightworthy configuration was responsible for the majority of the cost overruns on the ABL Block 2004 contract.
Aegis BMD	7.4	0.8	The prime contractor's cost and schedule performance reported here reflects that of only the contractor for the Aegis BMD interceptor (SM-3) and not of the entire Aegis BMD element. We note, in addition, that the cost and schedule variances do not account for overruns incurred from developmental problems with the interceptor's divert system. These efforts were removed from the SM-3 contract and not reported in the cost performance reports we received from MDA.
C2BMC	5.3	(0.4)	C2BMC work on the prime contract during fiscal year 2003 was completed under budget.
GMD	(138)	(50.9)	Developmental and delivery problems with the interceptor were the leading contributor to cost overruns and schedule slips during fiscal year 2003.
KEI	N/A	N/A	Because the prime contract was awarded in December 2003 (fiscal year 2004), no fiscal year 2003 data existed for an assessment of the contractor's cost and schedule performance.
STSS	(1.0)	(6.1)	Contractor cost and schedule performance steadily declined during fiscal year 2003 and into fiscal year 2004. In October 2003 alone, the prime contractor exceeded its budget by $3 million.

(Continued From Previous Page)

Dollars in millions

BMDS element	Cost variance	Schedule variance[a]	Comments
THAAD	(12.0)	(12.2)	The contractor's positive cost and schedule variance eroded somewhat during fiscal year 2003, which was driven by the missile component but offset by other THAAD components. With 49 percent of the THAAD contract completed, the prime contractor is, overall, under budget and ahead of schedule.

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

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

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

MDA Faces Many Key Risks in Developing and Fielding BMDS Elements

Our analysis of fiscal year 2003 activities indicates that there are key risks associated with developing and fielding BMDS elements. Key risks are those for which we found evidence of problems or significant uncertainties that could negatively affect MDA's ability to develop, demonstrate, and field a militarily useful capability within schedule and cost estimates. Key risks associated with BMDS elements expected to be fielded during Block 2004—Aegis BMD, GMD, and C2BMC—are exacerbated by the tight schedule to meet the September 2004 date for IDO.

Element-specific risks are summarized below. A more complete discussion of these risks can be found in the appendixes of this report.

ABL. The complexity and magnitude of integration activities to deliver a working system for the shoot-down demonstration have been substantially underestimated. Accordingly, the program continues to be at risk for additional cost growth and schedule slips. We also found that the uncertainty regarding the element's ability to control environmental vibration on the laser beam—jitter—is a serious performance risk for the Block 2004 aircraft. Furthermore, we note that weight distribution across the airplane may be a key risk for future blocks.

Aegis BMD. The program office is under a tight deadline to complete the development and testing of long-range surveillance and tracking software by the September 2004 date for IDO. By September, this software will not have been field-tested, and hence, its performance will be uncertain. However, program officials acknowledged that the greatest performance risk to the Aegis BMD program pertains to its interceptor's divert system, the subsystem that generates “divert pulses” to control the orientation and direction of the interceptor’s kill vehicle. Program officials do not expect to implement any design changes to the divert system for the first set of five missiles being procured. Even with a reduced divert capability, program officials affirm that the missile’s performance is adequate for Block 2004 threats. Finally, there are also questions about the contractor’s readiness to produce interceptors.

C2BMC. The C2BMC is tracking and mitigating key BMDS-specific risks pertaining to the fielding of the initial capability by September 2004 and the Block 2004 defensive capability by December 2005. Notably, development of the C2BMC element is proceeding concurrently with the development of other BMDS elements, and changes in one element’s design—especially in how that element interfaces with the C2BMC element—could cause temporary incompatibilities during Block 2004 integration that could delay fielding. In addition, the BMDS concept of operations continues to evolve, leading to uncertainties about how the C2BMC element will be operated. Finally, uncertainty regarding the reliability of communications links with the Aegis BMD element threatens to degrade overall system performance.

GMD. The GMD program faces significant testing and performance risks that are magnified by the tight schedule to meet the September 2004 date for IDO. Specifically, delays in flight testing—caused by delays in GMD interceptor development and delivery—have left the program with only limited opportunities before IDO to demonstrate the performance of fielded components and to resolve any problems uncovered during flight testing. In addition, uncertainty with the readiness of interceptor production could prevent MDA from meeting its program goal of fielding 20 interceptors by December 2005. Finally, an unresolved technical issue with the kill vehicle adds uncertainty to element performance.

KEI. From discussions with program officials, we found that KEI software costs could be underestimated, putting the program at risk for cost growth. The program office also acknowledges that it faces challenges in developing the first operational boost phase intercept capability that employs hit-to-kill concepts.

STSS. The STSS program is on track for completing activities leading to the launch of the two demonstration satellites in 2007, provided that unforeseen problems do not arise during the process of (1) testing, assembling, and integrating hardware components of the satellites, which have been in storage for 4 years, and (2) developing software and integrating software and hardware—areas that historically have been responsible for negatively affecting a program's schedule.

THAAD. The THAAD program office is on track to develop, demonstrate, and field the Block 2008 THAAD element within schedule and cost estimates, provided that the contractor performs as efficiently as it has in the past.

One risk area that covers the entire BMDS for Block 2004 (and future blocks) is whether the capabilities being developed and fielded will work as intended. As discussed above, testing to date has done little to demonstrate system effectiveness, because production-representative hardware is still being developed and has yet to be flight tested. Furthermore, tests to date have been developmental in nature and, accordingly, engagement conditions were repetitive and scripted. In the future, MDA is taking a number of actions to increase testing complexity and realism. However, it has no plans to conduct operational testing on the IDO or Block 2004 configurations being fielded.

An operational test assesses the effectiveness of the system against the known threat and its suitability in an environment that mimics expected use. U.S. law requires that such tests be carried out on major defense acquisition programs under the oversight and with the approval of DOT&E.[15] The law requires that DOT&E report test results to the Secretary of Defense and congressional defense committees before a full-rate production decision is made.[16] As the principal operational test and evaluation official within DOD, DOT&E is independent of program offices and reports directly to the Secretary.[17]

[15] 10 U.S.C. § 2399 (2000).

[16] Specifically, the law prohibits a program from proceeding beyond low-rate initial production (LRIP) until initial operational test and evaluation is completed. LRIP begins the "Production and Deployment" phase of the acquisition cycle and concludes with a full-rate production decision review to authorize full-rate production and deployment.

[17] 10 U.S.C. §139 (2000 & Supp. I 2001).

In establishing MDA, the Secretary of Defense specified that when a decision is made to transition a block configuration to a military service for procurement and operations, an operational test agent would be designated.[18] The Secretary specified further that an operational test and evaluation would be conducted at the end of the transition stage. In fielding IDO and the Block 2004 configuration, no decision is being made to transition the block configuration to a service. Thus, no operational test agent is being designated and no operational test and evaluation is planned. Furthermore, the fielding of IDO and the Block 2004 configuration is not connected to a full-rate production decision that would clearly trigger statutory operational testing requirements.

MDA plans to incorporate both developmental and operational test requirements in integrated flight tests. It will also conduct operational assessments that involve the warfighter. Nonetheless, because these tests are scripted by MDA, they do not provide the opportunity for an independent assessment of how the equipment and its operators will function under unscripted, unforeseen conditions. An independent and objective assessment would, instead, involve having an independent operational test agent plan and manage tests that demonstrate operational effectiveness and suitability and having DOT&E approve the test plans and report its assessment of the test results to the Secretary and Congress. Such independent, operationally realistic testing of a missile defense capability being fielded for operational purposes, which meets the statutory definition of "operational test and evaluation,"[19] would not be considered a developmental test and evaluation for which DOT&E is precluded from being assigned responsibility.[20]

Observations on the Usefulness of MDA Program Goals for Conducting Oversight

MDA revised its program goals in February 2004 to reflect that the first BMDS block—Block 2004—will cost $1.12 billion more but consist of fewer fielded components than originally planned. Despite these revisions, we observed shortcomings in how MDA defines its goals. Specifically, the goals do not provide a reliable and complete baseline for accountability

[18] The Secretary did not specify the operational test agent. The Army, Navy, and Air Force each have their own operational test agents who are independent of their program offices.

[19] 10 U.S.C. § 139(a)(2)(A) (2000).

[20] Id. §139(d).

purposes and investment decision making because they can vary year to year, do not include life-cycle costs, and are based on assumptions about performance not explicitly stated.

Program Cost and Content Goals Vary Year-to-Year

MDA's program goals can vary from year to year. The Block 2004 cost goal of $7.36 billion is actually a budget allocation for program activities associated with the block's development and fielding. The flexibility available in its acquisition strategy allows MDA to request additional funding for the second year of a block or defer or cancel program activities if the budget allocation is not sufficient to deliver the BMDS as planned. Because the budget (i.e., the cost goal) and program content are subject to change over the 2-year block period, the goal cannot serve as a reliable baseline for measuring cost, schedule, and performance status over time.

A comparison of MDA's fiscal year 2004 and 2005 budget submissions illustrates how the cost goal and the program content can vary from year to year. In fiscal year 2004, MDA's cost goal for Block 2004 was $6.24 billion. When MDA submitted its fiscal year 2005 budget, the Block 2004 cost goal had increased to $7.36 billion. Additionally, Aegis BMD interceptor inventory decreased from 20 to 9, the number of Aegis BMD destroyers upgraded for the long-range surveillance and tracking mission decreased from 15 to 10, and the potential operational use of ABL and the sea-based X-band radar as sensors is no longer part of Block 2004.

The 2004 and 2005 budget submissions also presented changes in cost estimates for Blocks 2006, 2008, and 2010. Estimated costs for Block 2006 increased by $4.73 billion, which is largely attributed to an increase in planned GMD funding by $2.23 billion for fiscal years 2005 through 2007. Estimated costs for Block 2008 decreased by $8.33 billion, from $16.27 billion to $7.93 billion. The decrease results largely from MDA's deferring KEI development to future blocks, which alone reduces estimated KEI costs for Block 2008 by $7.23 billion. Finally, estimated costs for Block 2010 increased by approximately $3.42 billion, of which $2.89 billion for the KEI program contributes to the increase.

MDA program officials acknowledged the increase in the Block 2004 cost goal but indicated that it should be seen as an adjustment resulting from internal realignments of funds over the fiscal years 2004-2009 Future Years Defense Plan. For example, as noted above, a significant portion of funds originally allocated to Block 2008 was redistributed to Blocks 2004, 2006, and 2010. Overall, between its 2004 and 2005 budget submissions, MDA's fiscal years 2004-2009 budget increased by about $3.23 billion, an increase of 6.5 percent. Program officials also noted that MDA's budget increase is the direct result of additional funds being planned for fielding, as opposed to an increase in funding for research and development.

While such flexibility is commonly seen with concept and technology development efforts, the Secretary of a military department is required by law to establish cost, schedule, and performance baselines for major defense acquisition programs entering the System Development and Demonstration (SDD)[21] phase of the acquisition cycle.[22] The program manager is required to report deviations from established baselines to senior DOD management. The baseline description also forms the basis of regular reporting to Congress on the status of the program through the Selected Acquisition Reports, including significant cost overruns.[23]

In establishing MDA in January 2002, the Secretary of Defense directed that BMDS elements enter the standard acquisition process at the Production and Deployment phase, which follows SDD. MDA has not addressed when, how, and if the BMDS, its block configurations, or its program elements will enter SDD—the typical initiation of an acquisition program. Accordingly, the agency has not established baseline descriptions for its block configurations that can be used to reliably measure the progress of the BMDS during development and for consistently reporting to Congress and senior DOD management on the cost, schedule, and performance status of the program.

[21] The SDD phase of acquisition was formerly known as Engineering and Manufacturing Development (EMD). Section 2435 of Title 10, U.S. Code, prohibits the obligation of funds for a major defense acquisition program after the program enters SDD without an approved baseline, unless the Under Secretary of Defense (Acquisition, Technology, and Logistics) specifically approves the funding.

[22] 10 U.S.C. § 2435 (2000 & Supp. I 2001).

[23] 10 U.S.C. § 2433 (2000).

Limited Reporting to Congress on Life-Cycle Costs

Congressional decision makers have traditionally used Selected Acquisition Reports to oversee the acquisition of weapon systems programs. Accordingly, MDA produces a Selected Acquisition Report annually, but because the missile defense program is not treated as being in the SDD phase of acquisition, reporting is limited. Programs that have not begun the SDD phase are not required to report life-cycle cost estimates, including all costs for procurement, military construction, and operations and maintenance, in the Selected Acquisition Report.[24]

Life-cycle cost estimates are important because an investment in a weapon system has ramifications beyond developing and procuring an inventory. Once operational, the system requires resources to ensure its continued operation, maintenance, and sustainment. For example, operators and maintenance personnel must be available to keep the system on alert and ready to perform its mission. Such costs—which MDA refers to as "operations and sustainment" costs—have been under review by MDA since 2003.

Original MDA estimates for operations and sustainment costs across the Future Years Defense Plan (fiscal years 2004-2009) ranged from $1.9 billion to $3.5 billion. However, during the fall of 2003, MDA worked with the military services to better define requirements, which lowered the estimates while still maintaining acceptable levels of readiness and alert. Since there is no precedent for estimating what the actual contractor logistical services costs might be, MDA agreed to fund the GMD contractor for these costs for fiscal years 2005 and 2006 and begin aggregating actual costs. MDA estimates that contractor logistical services will cost approximately $105 million in fiscal year 2005.

We note, in addition, that Congress expressed specific interest in obtaining life-cycle cost information for missile defense programs entering Engineering and Manufacturing Development (EMD), otherwise known as SDD. Specifically, Congress required MDA, with its statement of goals, to provide an annual program plan for each missile defense program that

[24] 10 U.S.C.§ 2432(c)(3)(A). See also 10 U.S.C. § 2434 (2000 & Supp. I 2001), which establishes the requirement for independent cost estimates of the full life-cycle cost of a program.

enters EMD.[25] Section 232(b) of the act further specified that each program plan is to include a funding profile (estimating significant research and development, procurement, and construction), together with the estimated total life-cycle costs of the program. During the period covered by our review, MDA did not provide any program plans detailing life-cycle costs.

MDA officials told us that the agency is working to better define its operations and sustainment costs and include total life-cycle costs in future Selected Acquisition Reports to Congress. They recognized that an understanding of total life-cycle costs for elements being fielded would help the military services plan their future budgets for procurement and operations and sustainment. However, MDA has not committed to when those reports would include total life-cycle costs.

Some Assumptions about Performance in Block 2004 Goals Are Unstated

BMDS performance goals are based on assumptions regarding the system's capability against threats under a variety of engagement conditions.[26] However, critical assumptions used in establishing these goals—such as the type and number of decoys—are not clearly explained. Without knowing these implicit assumptions, an understanding of the operational capability of the fielded system is incomplete.

As defined in table 8, MDA utilizes three performance metrics—probability of engagement success, defended area, and launch area denied—for measuring the capability of the Block 2004 BMDS to engage and negate ballistic missile attacks.

[25] *National Defense Authorization Act for Fiscal Year 2002*, Pub. L. No. 107-107, § 232(d), 10 U.S.C. § 2431 note (Supp. I 2001). The act's definition of EMD has since been revised so that the criteria do not apply to the "development phase" of a missile program but to "an acquisition program." *National Defense Authorization Act for Fiscal Year 2004*, Pub. L. No. 108-136, § 221(c)(1).

[26] Section 223a(c) of Title 10, U.S. Code, as added by section 223(a) of the *National Defense Authorization Act for Fiscal Year 2004* (Pub. L. No. 108-136), requires MDA to include, with the performance criteria in its annual budget justification, a description of the intended effectiveness of each planned development phase of the BMDS against foreign adversary capabilities.

Table 8: BMDS Performance Metrics

Performance metric	Definition
Probability of engagement success (P_{ES})	The probability that the BMDS hits, damages, and kills a booster, bus, or warhead in a ballistic missile attack. P_{ES} is derived from the probabilities associated with missile defense functions such as detection, track, discrimination, and hit-to-kill.
Defended area	The areas for which BMDS can provide protection. As a metric, it is generally represented as a map of the area that can be defended with at least one intercept opportunity when the attack is by ballistic missiles launched from a specified launch area.
Launch area denied	The launch area of those ballistic missiles capable of reaching defended areas and which the BMDS can engage; i.e., the area from which an enemy cannot attack without being engaged by the BMDS.

Source: Missile Defense Agency.

MDA assigned values to its performance metrics to communicate the defensive capability of the Block 2004 system against ballistic missile attacks but did not explain the assumptions underlying those values.[27] For example, although the probability of engagement success is affected by adversary parameters—trajectory, decoys, and warhead type—as well as the performance and orchestration of the defense elements, we found that these factors are not explicitly defined and provided in MDA's *Statement of Goals*. Because threat characteristics such as countermeasure sophistication and warhead dynamics all factor into the determination of the performance metrics, knowledge of these assumptions is vital to understanding the true capability of the system.

Conclusions

MDA's new acquisition strategy for acquiring ballistic missile defenses is designed to give MDA greater flexibility so it can, for example, more easily develop and introduce new technologies to address evolving threats. However, having such flexibility does not diminish the importance of ensuring accountability over the substantial investments in missile defense. In exercising their oversight and funding responsibilities, decision makers in Congress and DOD would benefit from having more information about the expected performance and costs of the BMDS.

[27] The values assigned are not presented in this report because they are classified.

Although MDA is executing a test program that aims, over time, to make its tests more complex and realistic, the agency has no plans to incorporate unscripted conditions found in operational testing. If independent, operationally realistic testing of block configurations being fielded were conducted and DOT&E approved, assessed, and reported on this testing, decision makers in Congress and DOD would have greater assurance that the fielded BMDS is an effective system when considering further investments in the system. With its statutorily based independence, DOT&E is in the best position to determine whether a weapon system can be trusted to work as intended when placed in the hands of the warfighter and to report operational test results objectively. We recognize that MDA may not have time before fielding IDO or Block 2004 to plan and carry out such testing. However, the agency should have the opportunity to conduct operational realistic testing of the Block 2004 configuration, once it is fielded.

Notwithstanding that interceptor inventory is being procured, operations and sustainment costs are being funded, and the IDO system is nearing the time when it will be fielded, MDA has not treated the development and deployment of this capability as an acquisition program (i.e., one that has entered the SDD phase) subject to reporting program status (from the baseline) and life-cycle cost information that Congress traditionally receives for its oversight responsibilities. Accordingly, accountability would be strengthened if MDA provided Congress with the program status and life-cycle cost information that is typically associated with SDD status. Such actions would also help the military services with their future budgeting for procurement and operations and sustainment costs. MDA officials told us that the agency is working toward including life-cycle cost information in these reports. Follow-through is needed.

Another means for MDA to strengthen accountability is through an improved definition of BMDS program goals and explanation of changes using the current reporting mechanisms. The Selected Acquisition Reports and MDA budget submissions would be much more useful for oversight and investment decision making if program goals for block configurations being fielded reflect program baselines that do not vary year-to-year; year-to-year changes in estimates are fully explained; full life-cycle costs for block configurations being fielded are presented; and assumptions behind performance goals are explicitly stated.

Recommendations for Executive Action

To provide increased confidence that a fielded block of the BMDS will perform as intended when placed in the hands of the warfighter and that further investments to improve the BMDS through block upgrades are warranted, we recommend that the Secretary of Defense take the following three actions:

- direct the Director, MDA, to prepare for independent, operationally realistic testing and evaluation for each BMDS block configuration being fielded and appoint an independent operational test agent to plan and conduct those tests;
- assign DOT&E responsibility for approving such test plans; and
- direct DOT&E to report its evaluation of the results of such tests to the Secretary and the congressional defense committees.

To provide decision makers in DOD and Congress with a reliable and complete basis for carrying out oversight of the BMDS program, we recommend that the Secretary of Defense take the following two actions:

- direct the Director, MDA, to establish cost, schedule, and performance baselines (including full life-cycle costs) for each block configuration of the BMDS being fielded and
- direct the Director, MDA, to explain year-to-year variations from the baselines in the Selected Acquisition Report to Congress.

Agency Comments and Our Evaluation

DOD's comments on our draft report are reprinted in appendix I. DOD did not concur with our three recommendations on operational testing and evaluation but concurred with our two recommendations regarding cost, schedule, and performance baselines.

In not concurring with our first recommendation, DOD stated that there is no statutory requirement for it to operationally test developmental items. That is, DOD is required only to operationally test a major defense acquisition program such as the ballistic missile defense system to assist in the decision as to whether to enter full-rate production. However, because of the capability-based structure under which MDA is operating, the decision to enter full-rate production will not be made in the foreseeable future and, in fact, may never occur. Given that significant resources have already been expended to procure inventory and field the system, and given that decision makers are continually being asked to invest further in the system, we believe DOD should provide evidence from independent, objective testing that the system will protect the United States as intended in an operationally representative environment.

In not concurring with our first recommendation, DOD also stated that MDA is attempting to incorporate operational test objectives into developmental tests. For example, MDA conducted an Aegis BMD intercept test in December 2003 that included some conditions likely to be encountered during an armed conflict. However, as noted in our recent report on missile defense testing, MDA has not yet begun to incorporate operational realism on tests of the GMD element, which provides the bulk of the initial BMDS capability. GMD flight tests leading up to IDO are constrained by range limitations, are developmental in nature and, accordingly, are executed with engagement conditions that are repetitive and scripted. It is unlikely that MDA will be able to make developmental tests completely operationally realistic. Developmental tests are, by definition, conducted under controlled conditions so that the cause of design problems can be more easily identified and fixed and the achievement of technical performance specifications can be verified. Additionally, because operational test conditions are more stressing, operational testing provides an opportunity to identify problems or deficiencies that might not be revealed in developmental tests but need to be addressed in subsequent BMDS blocks.

In not concurring with our second recommendation, DOD stated that DOT&E already has statutory responsibility for reviewing and approving operational test plans but is prohibited from approving plans for developmental testing. However, our recommendation is based on our view that the block configurations being fielded should be operationally tested. These tests would not be the developmental tests for which DOT&E is prohibited from approving. Because of its independence from the program, we believe DOT&E is in the best position to approve the plans for, and evaluate the results of, operational tests that are not required by statute-tests of block configurations being fielded that do not involve a full-rate production decision.

DOD also did not concur with our third recommendation that DOT&E report the results of operational tests to the Secretary of Defense and to Congress. In responding to this recommendation, DOD cited the existing statutory reporting requirements for DOT&E, under which it has assessed the MDA test program. However, for the reasons cited above, we continue to believe that operational tests of the BMDS configurations being fielded are needed. The statutory requirement for operational testing and for DOT&E's reporting responsibilities is not clearly triggered by the fielding of block configurations that do not involve a full-rate production decision. Also, although we recognize that DOT&E is providing an annual assessment of the BMDS to defense committees each year, we believe this assessment is limited. It is based on developmental tests that, because of their scripted nature, do not provide optimal conditions for assessing the system's readiness for operational use.

DOD also provided technical comments to this report, which we considered and implemented, as appropriate.

We are sending copies of this report to the Secretary of Defense and to the Director, Missile Defense Agency. 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 X.

R E Levin

Robert E. Levin
Director
Acquisition and Sourcing Management

List of Congressional Committees

The Honorable John W. 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 Jerry Lewis
Chairman
The Honorable John P. Murtha
Ranking Minority Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Comments from the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

9 APR 2004

Mr. Robert E. Levin
Director, Acquisition and Sourcing Management
U. S. General Accounting Office
441 G. Street, N.W.
Washington, DC 20548

Dear Mr Levin:

This is the Department of Defense's (DoD's) response to the GAO Draft Report, "MISSILE DEFENSE: Actions Are Needed to Enhance Testing and Accountability," dated March 9, 2004 (GAO Code 120252/GAO-04-409).

The DoD has reviewed the draft report. We do not concur with recommendations 1, 2, and 3, and concur with recommendations 4 and 5. Specific comments on each recommendation are enclosed. We also recommend some factual corrections. My action officers for this effort are COL Enrique Ramos, (703) 695-2680, enrique.ramos@osd.mil, and Lt Col Mark Arbogast, (703) 695-7328, mark.arbogast@osd.mil.

We appreciate the opportunity to comment on the draft report.

Sincerely,

for Glenn F. Lamartin
Director
Strategic and Tactical Systems

Attachment

GAO DRAFT REPORT – DATED MARCH 9, 2004
GAO CODE 120252/GAO-04-409

"MISSILE DEFENSE: Actions Are Needed to Enhance Testing and Accountability"

DEPARTMENT OF DEFENSE COMMENTS
TO THE RECOMMENDATIONS

RECOMMENDATION 1: The GAO recommended that the Secretary of Defense direct Director, MDA, to prepare for independent, operationally realistic testing and evaluation for each BMDS block configuration being fielded and appoint an independent operational test agent to plan and manage those tests. (p. 28/GAO Draft Report)

DOD RESPONSE: Non-Concur – Contingent upon the receipt of legislative authority to acquire developmental items for fielding, the Missile Defense Agency (MDA) will begin to field developmental blocks of the Ballistic Missile Defense System (BMDS) as soon as technologically possible, based on evidence of capabilities established through developmental testing. Although there is no statutory requirement to conduct operational testing with respect to developmental items, the Director, Operational Test and Evaluation (DOT&E), and the Service Operational Test Agencies' combined test teams are working with MDA and the prime contractors to combine operational testing objectives in test planning as systems mature. In accordance with section 2399 of title 10, United States Code, formal operational test and evaluation will be executed by a Service when an element of BMDS matures and transitions from MDA to the Service, and prior to entry into full-rate production.

RECOMMENDATION 2: The GAO recommended that the Secretary of Defense assign DOT&E responsibility for approving such test plans. (p. 28/Draft Report)

DOD RESPONSE: Non-Concur – Pursuant to section 139 of title 10, United States Code, DOT&E already has the statutory responsibility to review and approve operational test plans, but is prohibited from approving plans for developmental testing. DOT&E currently reviews the operational objectives for combined developmental testing / operational testing events and approves operational aspects of these test plans.

RECOMMENDATION 3: The GAO recommended that the Secretary of Defense direct DOT&E to report its evaluation of the results of such tests to the Secretary and the Congressional defense committees. (p. 28/Draft Report)

DOD RESPONSE: Non-Concur – DOT&E's reporting responsibilities are already established in statute. Section 139 of title 10, United States Code, requires that DOT&E submit an annual report, to the Secretary of Defense, Under Secretary of Defense (Acquisition, Technology and Logistics) and the Congress, on the adequacy of the Department's operational test and evaluation activities during the previous fiscal year. Section 2399 of title 10 requires that DOT&E submit a report, to the Secretary of Defense and the congressional defense committees prior to a decision to proceed beyond low-rate initial production, as to whether items or components tested during operational testing for a major defense acquisition program are effective and suitable for combat. Section 2366 of title 10 requires that the Secretary of Defense report, to the congressional defense committees prior to the decision to proceed beyond low-rate initial production, regarding the results of realistic survivability testing with respect to a major defense acquisition program. Section 232 of the National Defense Authorization Act for Fiscal Year 2002 imposes additional reporting requirements unique to ballistic missile defense. Specifically, section 232 requires that the Secretary of Defense submit an annual program plan, including a schedule of testing activities, to the congressional defense committees, and that DOT&E provide an annual assessment of MDA's test program during the preceding fiscal year, also to the congressional defense committees. As discussed above in the DOD Response to Recommendation 1, contingent upon receipt of legislative authority, MDA will begin to field blocks of the BMDS based on developmental testing, and formal operational test and evaluation will be executed by a Service when an element of BMDS transitions from MDA to the Service.

RECOMMENDATION 4: The GAO recommended that the Secretary of Defense direct the Director, MDA to establish cost, schedule, and performance baselines (including full lifecycle costs) for each block configuration of the BMDS being fielded. (p. 29/Draft Report)

DOD RESPONSE: Concur – The Department agrees with this recommendation regarding establishing cost, schedule, and performance baselines for each block configuration of the BMDS being fielded. Each year, in fact, MDA reviews and revises its goals based on the progress of development, in consultation with the missile defense oversight structure currently in place.

RECOMMENDATION 5: The GAO recommended that the Secretary of Defense direct the Director, MDA to explain year-to-year variations from the baselines in the Selected Acquisition Report to Congress. (p. 29/Draft Report)

DOD RESPONSE: Concur – The Department agrees with this recommendation.

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 and critical assets from short- and medium-range ballistic missile attacks. It will be fielded as part of the Block 2004 Ballistic Missile Defense System to engage enemy missiles in the midcourse phase of flight. Additionally, it will act as a forward-deployed sensor for surveillance and early tracking of long-range ballistic missiles. To provide these capabilities, the Missile Defense Agency (MDA) is adding new features to existing functionality offered by Navy ships.

The Department of Defense (DOD) budgeted about $4.8 billion for Aegis BMD development and fielding during fiscal years 2004 through 2009. Earlier, DOD expended approximately $2.9 billion between fiscal years 1996 and 2003 for related developmental efforts.

Fiscal Year 2003 Progress Assessment

The Aegis BMD element generally completed work planned for fiscal year 2003 on schedule. However, the program faces risks that include the uncertainty of software performance for the initial surveillance and tracking capability, questions about the contractor's readiness to produce interceptors, and concerns about the interceptor's divert system.

Schedule: In fiscal year 2003, the program office initiated software upgrades to enable Aegis ships to perform the ballistic missile defense mission, began a series of activities related to producing and delivering the Aegis BMD interceptor, and conducted ground and flight tests to verify Aegis BMD performance. Although the program suffered its first failed intercept attempt in June 2003, overall, four of five intercept attempts conducted by the Aegis BMD program have been successful.

Performance: The Aegis BMD element demonstrated the capability to intercept a non-separating target, that is, a target whose warhead has not separated from the booster. However, we were unable to fully assess progress in achieving performance goals during fiscal year 2003, because the program office began reporting performance indicators in calendar year 2004.

Cost: Our analysis of prime contractor cost performance reports shows that the interceptor contractor completed fiscal year 2003 work at slightly less cost than budgeted. However, we were unable to determine how work progressed on the interceptor's high-risk divert system—the component causing the greatest performance risk to the program—because that work was not reported in cost performance reports. Additionally, we could not readily assess cost and schedule performance of other Aegis BMD components associated with missile defense, because cost performance reports were not in a form we could use for our analysis, and these efforts did not undergo an integrated baseline review.

Risks: Program officials are working under a tight schedule to complete the development and testing of software intended to enhance surveillance and tracking functions. Officials said there is inadequate time to flight test these new functions before September 2004. Moreover, they share our assessment that the greatest performance risk to the Aegis BMD program pertains to development of the interceptor's divert system that steers the interceptor into the target. During a flight test in June 2003, subassemblies of the divert system failed, and the target was not intercepted. Program officials do not expect to implement any design changes to the divert system for the first set of five missiles being procured. Even with a reduced divert capability, program officials affirm that the missile's performance is adequate for Block 2004 threats. Finally, program officials share our concern that missile production and delivery is a program risk.

Aegis Ballistic Missile Defense

Background: Element Description

The Aegis Ballistic Missile Defense (Aegis BMD) element is a sea-based missile defense system that builds on the existing capabilities of Aegis-equipped Navy cruisers and destroyers. Aegis BMD is being designed to protect deployed U.S. armed forces and critical assets from short- and medium-range ballistic missile attacks. Key capabilities include the shipboard AN/SPY-1 radar, hit-to-kill interceptors,[1] and command and control systems to detect, track, and destroy enemy warheads in the midcourse phase of flight. Aegis BMD is also expected to be used as a forward-deployed sensor that provides surveillance and early tracking of long-range ballistic missiles to support the Ground-based Midcourse Defense (GMD) mission.

The program office is enhancing the existing Aegis Weapon System and Standard Missile (SM) currently installed on Navy cruisers and destroyers. The Aegis Weapon System was originally developed to protect U.S. Navy ships from air, surface, and subsurface threats. Planned hardware and software upgrades to the Aegis Weapon System will provide for enhanced tracking and target discrimination, which are functions needed to carry out the missile defense mission. The Aegis BMD interceptor, referred to as SM-3, is a solid propellant, four-stage, hit-to-kill missile designed to intercept ballistic missiles above the atmosphere. SM-3 makes use of the existing SM-2 propulsion stack (booster and dual thrust rocket motor) for the first and second stages. A third-stage rocket motor and a kinetic warhead (a hit-to-kill warhead known as the “kill vehicle”) complete SM-3.

The first increment of the Aegis BMD element is expected to deliver an operational capability in the 2004-2005 time frame as an interoperable element of the Ballistic Missile Defense System (BMDS). Known as Block 2004, this increment will inaugurate Aegis BMD’s dual role for the missile defense mission. First, the element will be used as a forward-deployed sensor for the surveillance and tracking of long-range ballistic missiles, and second, it will be used to engage and intercept short- and medium-range ballistic missiles. According to program officials, Block 2004 is being rolled out in three phases:

- **Initial fielding of the surveillance and tracking capability.** By September 2004, the Missile Defense Agency (MDA) aims to upgrade

[1] In this context, the missile defense community uses the terms “missile” and “interceptor” interchangeably.

three destroyers to be capable of performing the surveillance and tracking function in support of the GMD mission.

- **Initial fielding of an intercept capability.** By April 2005, two upgraded cruisers with an inventory of five interceptors are expected to be available for engaging short- and medium-range ballistic missiles.
- **Completion of Block 2004 upgrades of 13 Aegis-equipped ships.** By the end of December 2005, MDA aims to have a total of 10 Aegis destroyers available for performing the long-range surveillance and tracking function.[2] In addition, MDA is planning to place up to 10 interceptors on three upgraded cruisers for the engagement role.

Background: History

The Aegis BMD program evolved from efforts in the 1990s to demonstrate the feasibility of a missile defense capability from a ship-based platform. The first demonstration of that concept was the Navy's Lightweight Exoatmospheric Projectile (LEAP) program, which consisted of four flight tests conducted from 1993 through 1995. The LEAP program successfully married a lightweight exoatmospheric projectile—the kill vehicle—to an existing surface-to-air missile to show that the resulting interceptor could be launched from a ship.

Subsequent to this demonstration, in fiscal year 1996, the Navy and the Ballistic Missile Defense Organization[3] initiated the Navy Theater Wide missile defense program, the predecessor to Aegis BMD. Plans called for deploying the first increment of the Navy Theater Wide program—essentially the current Aegis BMD program—in 2010 and a final increment with an upgraded missile at a later, undefined date.

The Navy Theater Wide program included an associated effort, the Aegis LEAP Intercept (ALI) program, as a follow-on flight demonstration effort to the earlier LEAP project. The ALI program consisted of a series of flight tests that culminated in 2002 with two successful intercepts using an early

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

[3] The Ballistic Missile Defense Organization was officially renamed the Missile Defense Agency in 2002.

version of the SM-3 missile. The ALI program is the basis for the Aegis BMD Block 2004 program.

Background: Developmental Phases

Aegis BMD development and fielding is proceeding in a series of planned 2-year blocks known as Blocks 2004, 2006, and 2008. Furthermore, funding has been planned for Block 2010, but the configuration of this block has not been defined by MDA.

Block 2004. Block 2004 is the first fielded increment to protect deployed U.S. forces and other assets from short- and medium-range ballistic missile attacks. Aegis BMD will also be used as a forward-deployed sensor to provide surveillance and early tracking of long-range ballistic missiles to support the GMD mission.

Block 2006. The Aegis BMD Block 2006 configuration builds on the Block 2004 capability. MDA plans to add the capability to defeat long-range ballistic missiles with limited countermeasures, to increase Aegis BMD's role as a remote sensor, and to assess emerging technologies for the element's missile.

Block 2008. The Aegis BMD Block 2008 configuration will incorporate enhancements to the AN/SPY-1 radar that are expected to improve the radar's discrimination and command and control functionality so that the element can engage multiple threats simultaneously.

Progress Assessment: Schedule

The Aegis BMD element generally completed work planned for fiscal year 2003 on schedule. Achievements included initiating Aegis Weapon System upgrades on existing ships, beginning activities for the production and delivery of SM-3 missiles, and accomplishing test events. However, problems that arose with the divert system onboard the interceptor's kill vehicle during flight-testing have affected future test events causing delays and the modification of test plans.

Aegis Weapon System Software Upgrades: Fiscal Year 2003 Activities Completed on Schedule

Aegis BMD program officials told us that they expect to eventually modify 18 Aegis ships with enhanced surveillance, tracking, and intercept functions to make them capable of performing the BMD mission. These upgrades will improve the capability of the element's AN/SPY-1 radar to identify the true target (discriminate), enable accurate tracking of long-range ballistic missiles in support of GMD operations, plan engagements, and launch an SM-3 missile to engage a ballistic missile threat. To achieve this enhanced functionality, the Aegis BMD program office is upgrading the Aegis Weapon System of designated ships through a series of software builds or computer programs referred to as CP3.0E, CP3.0, and CP3.1.

Aegis BMD program officials stated that they originally planned two software builds—CP3.0 and CP3.1—as incremental increases to the Block 2004 capability through the end of 2005. The program expected that the CP3.1 software build, once developed and installed on Aegis ships, would enhance the existing combat system so that upgraded ships could perform the BMD mission. However, in response to the Presidential Directive to begin fielding a set of missile defensive capabilities in 2004, the Aegis BMD element began the development of an early, interim build referred to as "CP3.0E." Several software development activities completed in fiscal year 2003 pertain to this build. CP3.0E is to be installed in one or more destroyers by September 2004, but it will enable these destroyers only to surveil and track enemy ballistic missiles. The ships will not be capable of launching interceptors to engage those missiles. According to program documentation, when CP3.0E is installed on ships at sea by September 2004, the program office will have achieved initial defensive operations for the Aegis BMD Block 2004 surveillance and tracking mission.

MDA expects CP3.0, the next software build, to augment the surveillance and tracking capability of CP3.0E with an initial engagement capability for Aegis cruisers. The availability of CP3.0 on ships at sea by April 2005[4] enables initial defensive operations for the Aegis BMD Block 2004 engagement mission. Although CP3.0 allows ships to launch SM-3 missiles, this capability applies only to Aegis cruisers and not to Aegis destroyers. The capability to intercept short- or medium-range ballistic missiles is limited to the single cruiser that will be available in April 2005. The third version of the computer program—CP3.1—adds ship defense and planning support for cruisers. MDA intends for CP3.1 to be installed by December 2005, and it is the last software upgrade planned for the Block 2004 time frame.

[4] CP3.0 will be available for installation on the Aegis cruiser in December 2004 for testing.

In fiscal year 2003, the program office conducted activities related to the development of the CP3.0E and CP3.0 software builds. All activities occurred within the expected schedule. The major event for CP3.0E was the July 2003 In Process Review. This review ensured that CP3.0E development and installation were on track to occur as planned. The CP3.0 System Design Disclosure, which occurred in March 2003, defined the design of CP3.0 and allowed the program office to proceed with the development of this software build. The program expects to continue developing CP3.0 and CP3.1 in fiscal year 2004 and to install CP3.0E on designated ships.

As software builds are completed and installed, Navy cruisers and destroyers will become available to perform their expected missions. As indicated by program officials, table 9 summarizes the availability of Aegis ships for the BMD mission in the Block 2004 time frame.

Table 9: Planned Aegis Ship Availability for the BMD Mission (Block 2004)

Ship function	September 2004	December 2004	April 2005	December 2005
Destroyers				
Capable only of surveillance and tracking (no engagement capability)	3[b]	5	9	10[c]
Cruisers[a]				
Capable of surveillance, tracking, and engagement	0	1	2	3
Total destroyers and cruisers available for BMD mission	**3**	**6**	**11**	**13**

Source: Missile Defense Agency.

[a]Total number of Aegis cruisers includes one being used as a test ship.

[b]One of the three surveillance and tracking ships will be delivered in October 2004.

[c]15 long-range surveillance and tracking “equipment sets” will be available at this time, but installations may not be completed owing to the ships’ operational schedules. The remaining 5 upgrades are planned for the Block 2006 time frame.

SM-3 Missile Development and Delivery: Progress Being Made but Challenges Remain

In fiscal year 2003, the Aegis BMD program office undertook a series of missile-related activities to begin procuring missiles for delivery in fiscal year 2004. The Aegis BMD element is developing evolving configurations of the SM-3 missile. The SM-3 “Block 0” configuration, which is used in Block 2004 flight-testing, is capable of intercepting simple non-separating targets. The “Block I” SM-3 configuration will be fielded as part of the BMDS Block 2004 defensive capability and provides a rudimentary target discrimination capability. Subsequent SM-3 configurations beyond Block I will not be available until calendar year 2006. Table 10 lists those activities and their respective completion dates.

Table 10: Missile-Related Activities, Fiscal Year 2003

Activity	Purpose	Date completed
SM-3 Block I Critical Design Review	Assess maturity of Block I	May 2003
SM-3 Block I Design Verification Tests	Verify design of Block I missiles	Ongoing
SM-3 Block I Production In Process Review	Assess Block I production readiness	Sept. 2003
SM-3 Nosecone Critical Design Review	Assess maturity of missile nosecone	Oct. 2003

Source: Missile Defense Agency.

The missile-related activities shown in table 10 occurred as planned, with the exception of the missile nosecone critical design review. Program officials stated that a delay of less than 3 months occurred because the testing facility was not available as originally planned. Table 11 summarizes the delivery of SM-3 missiles in the Block 2004 time frame.

Table 11: SM-3 Missiles Delivered, Expended, and in Inventory

Missile delivery	Up to Sept. 2004	Sept. 2004– Dec. 2004	Dec. 2004– Apr. 2005	Apr. 2005– Dec. 2005	Total missiles (Block 2004)
Block 0 missile					
Delivered	3	0	0	0	**3**
Expended	3	0	0	0	**3**
Inventory	0	0	0	0	**0**
Block I missile					
Delivered	5	0	2	4-7	**11-14**
Expended	0	0	2	1	**3**
Inventory	5	0	0	3-6	**8-11**

Source: Missile Defense Agency.

Note: Inventory = delivered minus expended.

Testing: Ground and Flight Testing Conducted with Mixed Results

The Aegis BMD program conducts both ground- and flight-testing to validate Aegis BMD's performance. The program office expects flight-testing to progressively demonstrate the element's capability to engage ballistic missile targets under increasingly complex conditions. Since 1999, the program conducted three flight tests (non-intercept attempts) to demonstrate basic missile functionality, such as booster performance and stage separation. During this same time frame, there have also been five intercept flight tests using the SM-3 missile. Of the five attempts, four were successful intercepts.

Ground Testing

Ground testing provides the opportunity to validate the flight-worthiness of Aegis BMD subcomponents on the ground before they are used in flight tests. In fiscal year 2003, ground-testing activities focused on the SM-3 missile and a redesigned 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. Ground tests of the SDACS were conducted to verify its readiness for flight-testing. When the SDACS ground test program demonstrated good performance with the simpler, more producible SDACS design, the Aegis BMD program office gave approval for its use in flight mission 5 (FM-5). Despite of successful ground testing, the SDACS subcomponent did not perform as desired in flight. The program office is investigating the cause of the failure, but a resolution is not expected until sometime in early 2004. As indicated by program officials, table 12 shows key ground tests planned for fiscal year 2003.

Table 12: Aegis BMD Ground Tests

Test event	Scheduled date	Objectives	Outcome
SDACS Monolithic Developmental Unit 1	Feb. 2003	Validate design of new SDACS	Objectives achieved
SDACS Monolithic Developmental Unit 2	May 2003	Validate design of new SDACS	Objectives achieved
SDACS qualification	June 2003	Confirm readiness of new SDACS for use in FM-5	Objectives achieved
Third stage rocket motor qualification	Sept. 2003	Validate material replacements and design changes in the rocket motor	Not performed owing to safety shutdown of test lab

Source: Missile Defense Agency.

Program officials stated that the only ground test that was scheduled to occur in fiscal year 2003, but did not, was the qualification testing of the third-stage rocket motor. The officials told us that the test could not be performed as scheduled, because a safety shutdown at the test facility occurred because of an explosion in another test area at that facility. They noted that modifications are being made to prevent similar incidents. Repairs are expected to continue well into the second quarter of fiscal year 2004, after which rocket motor testing can be resumed.

Flight Testing

The program office conducted three flight missions—FM-4, FM-5, and FM-6—in fiscal year and calendar year 2003. With the exception of FM-5, these tests proceeded as planned. FM-4, which occurred in November 2002, marked the start of the Aegis BMD Block 2004 flight test phase. FM-4's primary test objective was to verify an ascent phase intercept against a non-separating ballistic missile target using the Block 0 SM-3 missile, and the objective was achieved. FM-5 had objectives similar to those of FM-4, viz., to intercept an ascending non-separating target. The test also was to demonstrate the operation of the redesigned SDACS in flight. In the end, FM-5 did not achieve an intercept because the SDACS did not perform as expected.[5] FM-6, a third test with objectives similar to those of FM-5, occurred later in calendar year 2003. Because of technical issues that arose in FM-5, the program office delayed FM-6 from September 2003 to December 2003 and modified the test plan. In particular, the program omitted its plan to exercise the full functionality of the newly designed SDACS, which failed during FM-5. Table 13 provides a summary of the flight tests.

[5] The Aegis BMD program office believes that the root of the failure can be traced to a defective "diverter ball." This failure is discussed in more detail later in this appendix.

Table 13: Aegis BMD Flight Tests

Test event	Completed date	Objectives	Outcome
FM-4	Nov. 2002	Ascent-phase intercept	Intercept achieved
FM-5	June 2003	Ascent-phase intercept; demonstration of new SDACS	Intercept not achieved
FM-6	Dec. 2003	Ascent-phase intercept; demonstration of connectivity with BMDS	Intercept achieved; FM-6 originally scheduled for Sept. 2003

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

Progress Assessment: Performance

Operational Performance of Aegis BMD Remains Uncertain

The Aegis BMD program has demonstrated the capability to intercept a non-separating target through its successes in FM-2, FM-3, FM-4, and FM-6. These successes are noteworthy, given the difficulty of "hit-to-kill" intercepts. DOT&E's fiscal year 2002 Report to Congress noted the successes but pointed out that the flight tests were developmental in nature and neither operationally realistic nor intended to be so. Test scenarios and target "presentation"[6] were simple compared with those expected to be encountered during an operational engagement. Furthermore, separating targets,[7] which pose a particular challenge to the Aegis BMD element, will not be assessed until FM-8 is conducted in 2005. While MDA is increasing the operational realism of its developmental flight tests—e.g., the Aegis Ballistic Missile Defense program employed an operational crew in FM-6—tests completed to date are highly scripted.

The Aegis BMD program developed a set of performance indicators that provides a top-level characterization of element effectiveness. We were unable to fully assess progress in achieving performance goals during fiscal

[6] The target flew a trajectory so that it presented a large cross section to the radar.

[7] A separating target is one where the warhead separates from the spent booster of the missile.

year 2003, because the program office began reporting performance indicators in calendar year 2004.

Progress Assessment: Cost

DOD expects to invest about $4.8 billion in Aegis BMD research and development from fiscal year 2004 through 2009. This is in addition to the $2.9 billion invested from fiscal year 1996 through 2003.

The program uses most of the funds it receives to fund the element's prime contract. In fiscal year 2003, the contractor completed all development work slightly under cost and ahead of schedule. However, because of early development problems with the SM-3 missile, the contractor incurred a cumulative cost overrun of about $39 million at the contract's completion in August 2003.

Program Cost: Aegis BMD Program Costing Approximately $800 Million per Year

Aegis BMD costs for the next 6 fiscal years are expected to be around $4.8 billion. This includes funds for Blocks 2004, 2006, and 2008 as well as portions of Block 2010. Also included is cooperative work between the United States and Japan on SM-3 component development. Table 14 shows the expected costs of the program by fiscal year through 2009, the last year for which MDA published its funding plans.

Table 14: Aegis BMD Planned Cost

Dollars in millions of then-year dollars

	Fiscal year						
Block	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Block 2004	$641	$966	$178	$0	$0	$0	**$1,785**
Block 2006	24	106	675	776	50	0	**1,631**
Block 2008	0	0	20	145	534	435	**1,134**
Block 2010	0	0	0	8	30	94	**132**
Cooperative	53	72	25	0	0	0	**150**
Total	**$718**	**$1,144**	**$898**	**$929**	**$614**	**$529**	**$4,832**

Source: Missile Defense Agency.

In fiscal years 2002 and 2003, MDA expended $446.5 million and $384.3 million, respectively, to develop the Aegis BMD element. Including these funds, the Navy and MDA have expended approximately $2.9 billion to develop a sea-based missile defense capability since the Navy Theater Wide program began.

Prime Contractor Fiscal Year 2003 Cost and Schedule Performance: Performance Improved, but Cost Overruns on the Missile Remain

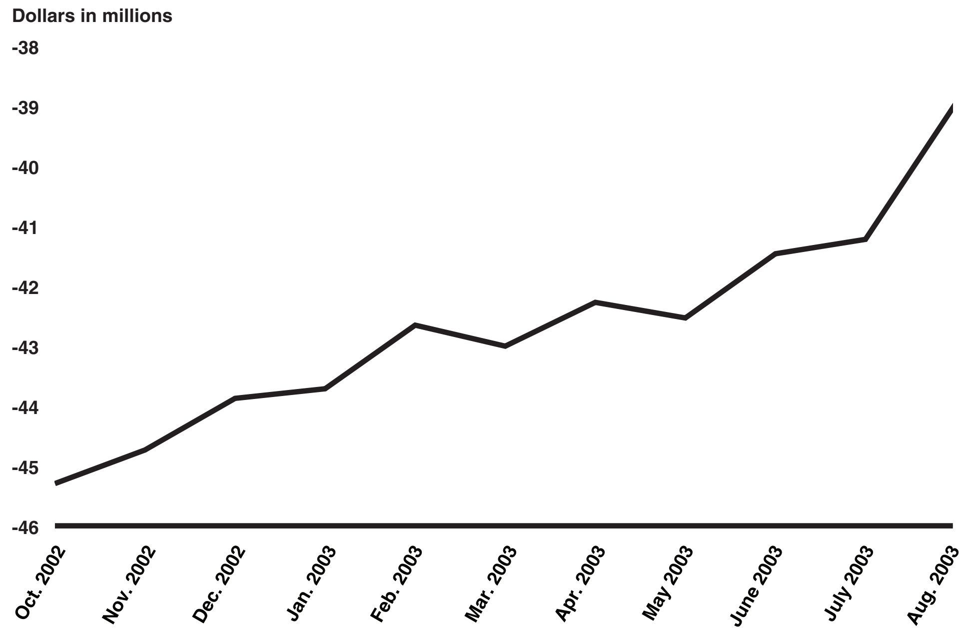
The prime contract consumes the bulk of the program's budget: about 84 percent of the Block 2004 budget supports the prime contractor team and 16 percent supports government efforts. Up until 2003, seven separate contracts covered the development of element components—the Aegis Weapon System, the Vertical Launch System, and the SM-3 missile. Late in the fiscal year, MDA awarded new contracts and reduced the number of contracts to two, an Aegis Weapon System contract and an SM-3 contract. The Aegis Weapon System contract covers all Block 2004 activities. It also provides for initial future block definition activities for Blocks 2006, 2008, and 2010. The SM-3 contract is similarly structured.

We used contractor Cost Performance Reports to evaluate the cost and schedule performance of the SM-3 contractor. The government routinely uses these 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—activities costing less or completed ahead of schedule—are generally considered as good news and negative variances—activities costing more or falling behind schedule—as bad news. According to the Aegis BMD program office, contractors produce Cost Performance Reports for the various components of the Aegis BMD element, such as the Aegis Weapon System and the SM-3 missile. However, we were able to assess cost and schedule performance only for the SM-3 missile. Cost Performance Reports associated with missile-defense activities for the other components were not in a form we could use for our analysis, and these efforts did not undergo an integrated baseline review. In the future, the new contracts will provide Cost Performance Reports for both the Aegis Weapon System and SM-3 missile.

The SM-3 development contract accounts for approximately 50 percent of Aegis BMD Block 2004 development costs. Our analysis of SM-3 missile Cost Performance Reports shows that the contractor generally improved its cost and schedule performance throughout fiscal year 2003. During this time, the SM-3 missile contractor spent $7.4 million less than originally budgeted and completed planned work slightly ahead of schedule. In addition, in fiscal year 2003, work efforts on major components of the SM-3 were completed generally within their estimated budget and slightly ahead of schedule. The contractor's improved performance in fiscal year 2003 resulted, in part, because in March 2003 the program removed the majority of the SDACS work from the SM-3 contract. As a result, the contractor was no longer required to incorporate SDACS activities, which had been the primary cause of prior cost and schedule growth, when providing Cost Performance Reports.

Despite improved performance in fiscal year 2003, the contractor continued to carry a negative cost and schedule variance from problems that occurred in prior years. As figures 2 and 3 illustrate, the SM-3 contractor entered fiscal year 2003 with cost overruns of approximately $46 million and with uncompleted work valued at $4.6 million. By August 2003, however, the contractor reduced its cost overrun and improved its schedule performance. At its completion, the SM-3 contract exceeded its budget by $39 million. According to the contractor, technical problems with the development of the SDACS, kill vehicle, rocket motor, and guidance section, as well as failures during flight and ground tests, were responsible for the majority of the cost overrun on the SM-3 contract.

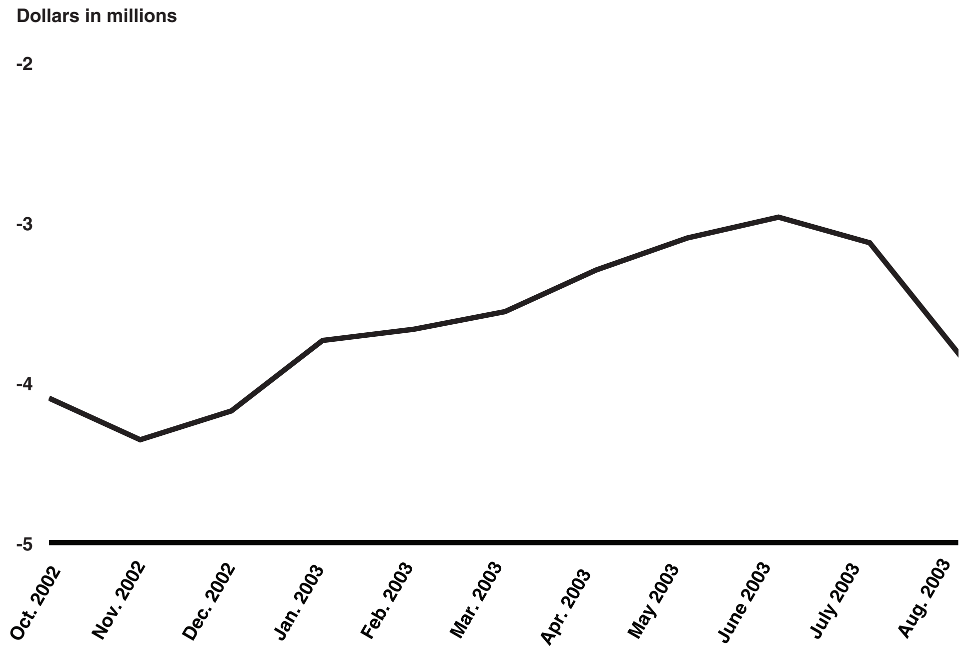
Figure 2: Fiscal Year 2003 Cost Performance (SM-3 Contract Only)



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

Note: Contract ended in August 2003; therefore, there is no reported September 2003 cost variance.

Figure 3: Fiscal Year 2003 Schedule Performance (SM-3 Contract Only)



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

Note: Contract ended in August 2003; therefore, there is no reported September 2003 schedule variance.

Program officials told us that the majority of the technical problems associated with SM-3's development, with the exception of the SDACS, have been resolved. The officials said that they do not expect these issues to cause negative variances on the new missile contract. However, technical problems associated with the SDACS could continue to affect cost and schedule performance on the new missile contract.

Program Risks

Based on our assessment of fiscal year 2003 activities, we found that the Aegis BMD program faces key risks in fielding the planned initial capability by September 2004 and the Block 2004 defensive capability by December 2005. These risks include the uncertainty of CP3.0E software performance at the time of initial fielding, questions about the contractor's readiness to produce interceptors, and concerns about SDACS development.

Uncertainty of CP3.0E Software Performance

Program officials are concerned with the inability to test the CP3.0E software in an operational environment (e.g., during a flight test) before September 30, 2004, when the element is fielded for its surveillance and tracking role. Officials told us that there is not adequate time to test the new surveillance and tracking functionality before initial defensive operations are declared, but risk reduction efforts (such as testing earlier builds of the software) are in place to minimize potential problems. Although the risk reduction efforts under way would not validate the full functionality of CP3.0E, the officials expect that these efforts will provide increased confidence that the CP3.0E software will perform as desired at the time of initial defensive operations.

They noted that the need to deliver and install CP3.0E before September 30, 2004, was driving much of the schedule risk. Should the CP3.0E effort fall behind schedule, the program would need to compress its schedule to meet the deadline for initial defensive operations (IDO). Research pertaining to estimating the level of effort in developing software, however, has shown that when schedules are compressed, the quality of the software effort can be compromised.

Contractor's Readiness to Produce Interceptors

We found that missile production and delivery is a key program risk; program officials concurred with our assessment. They indicated that current MDA plans call for the delivery of 11 to 14 SM-3 missiles by the end of 2005.[8] Program officials also stated that the first five missiles are being produced at the contractor's research and development facility. Highly trained technical engineers, with manufacturing observers, are building these developmental missiles. Future production missiles will be built by manufacturing labor with engineering oversight as needed. A transition to this production is planned but will not occur until production begins on the next set of 12 missiles.

Concerns about SDACS Development

We found that the greatest performance risk to the Aegis BMD program pertains to the development of the SDACS, the subsystem that generates divert pulses to control the orientation and heading of the interceptor's kill vehicle; program officials agreed with our assessment. Ground tests conducted in 2002 revealed problems with the initial SDACS design,

[8] Of the 14 missiles, MDA has plans to field 8 to 11.

specifically with the subassemblies supporting the operation of the divert pulses. To find a solution to these problems, MDA in 2002 pursued multiple designs for the SDACS subassemblies of the kill vehicle, intending to use the most promising for the program. On the basis of ground test results, MDA selected a single-piece variation of the original design (referred to as the "Monolithic Design"). This design employs a multi-pulse concept whereby (1) a sustain-mode is used to provide low-energy divert and attitude control of the kill vehicle and (2) an energetic pulse-mode is available for maximum divert capability.

When the Monolithic SDACS design with its sustain- and pulse-mode divert capability proved successful in ground testing, the program planned to flight-test it during FM-5. However, during FM-5, the subassemblies supporting the energetic pulse-mode failed, causing the kill vehicle to be less maneuverable. Program officials stated that they are investigating the failure and believe that the "diverter ball," which acts as a valve to control the pulse, caused it. Incorporating the high-energy pulse into the SDACS increased internal operating pressures, and under the thermal stress, the protective coating of the diverter ball cracked, disabling normal SDACS operation.

Aegis BMD program officials stated that they do not expect to implement any design changes related to pulse-mode divert capability in 2004. Nonetheless, MDA is moving ahead with the procurement of 5 of the 20 Block 2004 missiles utilizing the Monolithic SDACS with reduced divert capability. According to program officials, these less-capable missiles provide a credible defense against a large population of the threat and can be retrofitted to support pulse-mode operations upon the completion of design updates and testing.

Without the energetic pulse-mode, performance against certain threats is limited, because the kill vehicle has less divert capability to compensate for initial targeting errors. This degradation is threat-dependent, that is, not significant for non-separating targets because the kill vehicle typically does not have to radically change course to engage a warhead attached to the booster tank. However, separating threats under specific scenarios may be problematic. The kill vehicle may need to expend additional energy to change course and engage a warhead that is physically separated from its booster tank.


Source: Missile Defense Agency

Appendix III Summary

Airborne Laser

Program Description

The Airborne Laser (ABL) is being developed to shoot down enemy missiles during the boost phase of flight. Installed onboard a Boeing 747 aircraft, ABL is designed to use a high-energy chemical laser to rupture the enemy missile's motor casing, causing the missile to lose thrust or flight control. As part of its Block 2004 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.

The Department of Defense (DOD) budgeted about $3.1 billion for ABL development during fiscal years 2004 through 2009. Earlier, the Air Force invested approximately $1 billion from 1996 through 2001, and MDA expended about $1 billion in 2002 and 2003 for related developmental efforts.

Fiscal Year 2003 Progress Assessment

Activities in fiscal year 2003 progressed much more slowly and were more costly than anticipated. Nearly all hardware deliveries, integration activities, and test events slipped. The program's underestimation of the complexity of integrating ABL subcomponents into a working system, in particular, resulted in significant cost growth and delays during fiscal year 2003.

Schedule: The ABL program continued with the development of the prototype aircraft, but as noted above, fiscal year 2003 activities progressed more slowly than anticipated. For example, four of six key test events were either deferred indefinitely or delayed over a year. Furthermore, quality issues and difficulty with integration activities resulted in the slip of a critical test milestone—the demonstration of individual laser modules linked together to form a single laser beam, known as "First Light." At the end of fiscal year 2003, the expected date for this demonstration was March 2004, but the event continues to slip. As a consequence of the test delays, the lethal demonstration continues to be pushed back.

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. However, performance indicators used by the program office to monitor performance indicate that 9 of 12 of the indicators are at risk in achieving Block 2004 goals.

Cost: Our analysis of prime contractor cost performance reports indicates that ABL cost performance deteriorated throughout fiscal year 2003. The contractor overran budgeted costs by $242 million and could not finish $28 million worth of work as planned. The underestimated complexity of integrating ABL subcomponents into a working system was the primary driver for the cost growth.

Risks: Our analysis indicates that the complexity and magnitude of integration activities—delivering a working system for the lethal demonstration—have been substantially underestimated. Accordingly, the program continues to be at risk for cost growth and schedule slips. In addition, a major performance risk for ABL Block 2004 involves controlling and stabilizing the high-energy laser beam so that vibration does not degrade the beam's aimpoint. Program officials stated that they are working to resolve this issue but cannot demonstrate final resolution before flight testing in 2005.

Airborne Laser

Background: Element Description

The Airborne Laser (ABL) element is a missile defense system designed to shoot down enemy missiles during the boost phase of flight, the period after launch when the missile is powered by its boosters. As an element of the Missile Defense Agency's (MDA's) Boost Defense Segment,[1] ABL is expected to engage enemy ballistic 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 motor casing, causing the missile to lose thrust or flight control. ABL's goal 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 (ICBMs).[2] In addition, ABL could be used as a forward-deployed sensor to provide accurate launch point, impact point, and trajectory data of enemy missiles to the overarching Ballistic Missile Defense System (BMDS) in support of engagements by other MDA elements.

The ABL element consists of the following three major components integrated onboard a highly modified Boeing 747 aircraft.[3] In addition, ground support infrastructure for chemical storage, mixing, and handling is a necessary component of the element.

- **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. By using a defensive weapon that incorporates the speed of light, ABL can destroy missiles more quickly, giving it a significant advantage over conventional boost-phase interceptors.

[1] The Boost Defense Segment includes all elements of the BMDS that defeat ballistic missiles during the boost phase of flight.

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

[3] These modifications include: the installation of miles of wiring, grafting large sheets of titanium to the plane's underbelly, and adding a 12,000-pound turret to house the 1.5-meter telescope through which the laser beams are fired.

- **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 is expected to plan and execute the element's defensive engagements. It is being designed to work autonomously using its own sensors for launch detection, but it could also receive early warning data from other external sensors.

Background: History

ABL's current development is based on more than 25 years of scientific research in the Departments of Defense and Energy. The program evolved primarily from airborne laser laboratory research, which developed applications for high-energy lasers. The laboratory's research culminated in a demonstration showing that a low-power, short-range laser was capable of destroying a short-range, air-to-air missile.

In 1996, the Air Force initiated the Airborne Laser program to develop a defensive system that could destroy enemy missiles from a distance of several hundred kilometers. Developmental testing for the program was expected to conclude in 2003 with an attempt to shoot down a short-range ballistic missile target. However, in 2002, management authority and funding responsibility transferred from the Air Force to MDA. In accordance with MDA planning, the Airborne Laser program restructured its acquisition strategy to conform to a capability-based approach.

Background: Developmental Phases

ABL development is proceeding in a series of planned 2-year blocks. The near-term blocks are known as Blocks 2004, 2006, and 2008. Other blocks may follow, but on the basis of recent budget documentation, MDA has not yet defined their content.[4]

[4] MDA's fiscal year 2005 budget (submitted in February 2004) indicates that the ABL program is undergoing some form of restructuring. Also, the program manager stated that the content of Blocks 2004, 2006, and 2008 would be changing: less focus on an operational capability and more focus on technology demonstration. Accordingly, procurement of the second ABL aircraft for Block 2008 has been deferred indefinitely.

Block 2004. The overall Block 2004 goal is to demonstrate the feasibility of the prototype ABL aircraft to defeat—via directed laser energy—a short-range, threat-representative ballistic missile. This concluding test event generally is referred to as the lethal shoot-down demonstration. MDA has no plans to deliver an ABL contingency capability in the Block 2004 time frame.

Block 2006. The Block 2006 ABL program makes use of the Block 2004 aircraft, but the block's focus is on testing, interoperability with the BMDS, and increased supportability for an emergency operational capability.

Block 2008. The program expects to procure a second, upgraded ABL aircraft in the Block 2008 time frame. It will incorporate upgrades for enhanced lethality and increased operational suitability. Block 2008 will also focus on making ABL more affordable.

Progress Assessment: Schedule

During fiscal year 2003, the ABL program planned to complete a series of activities in preparation for Block 2004. Although the program made some progress, planned activities progressed much more slowly than anticipated. These activities included the following:

- designing, fabricating, and delivering subcomponent hardware critical to the operation of the ABL element (hardware delivery);
- integrating and testing subcomponents as functioning components; and
- completing a test milestone referred to as "First Light," the first demonstration—in a ground-test facility—of the integration of six individual laser modules to produce a single beam of laser energy.

Hardware Delivery: Delays Affect Entire Program

ABL contractors delivered critical ABL element hardware during fiscal year 2003, including subcomponents of the BC/FC component. However, in each case, hardware delivery was originally scheduled for the end of fiscal year 2002. (See table 15.) Because these hardware deliveries were delayed, the schedule for subsequent integration and demonstration activities was also affected.

Table 15: ABL Program Hardware Deliveries, Fiscal Year 2003

Hardware delivery	Scheduled date	Completion date
Delivery of Active Ranger System (ARS)[a]	Sept. 2002	Feb. 2003
Delivery of Target Illuminator Laser (TILL)[b]	Aug. 2002	Nov. 2002
Delivery of Beacon Illuminator Laser (BILL)[c]	Aug. 2002	Nov. 2002
Final Delivery of High-Energy Laser Modules	Sept. 2002	Apr. 2003

Source: Missile Defense Agency.

[a]The Active Ranger System is the laser that sits atop the aircraft and provides preliminary range and tracking data of a target missile.

[b]The Target Illuminator Laser is the laser that sweeps, locks, and determines the aimpoint on the target.

[c]The Beacon Illuminator Laser is the laser that bounces a beam off the target missile back to the aircraft and thus measures the amount of atmospheric disturbance between the aircraft and the target.

Integration and Testing: Key Test Events Delayed More Than a Year

Table 16 summarizes the status of major Block 2004 ABL test events, scheduled sometime during fiscal year 2003. As illustrated, four of the six test events were either deferred or delayed over a year due to late hardware and software availability, subcomponent test failures, and numerous design flaws. Consequently, the lethal demonstration—the focus of Block 2004 development—has been delayed until February 2005 at the earliest. Other than the surveillance and tracking tests, which were conducted in flight and have been completed, all scheduled testing listed in table 16 will be performed in ground facilities, such as the System Integration Laboratory (SIL) at Edwards Air Force Base, California.

Table 16: ABL Program Test Events, Fiscal Year 2003

Test event	Scheduled date	Completion date	Event description
Surveillance flight tests (6 tests total)	N/A	July 2002–Jan. 2003	Track of fighter aircraft and Lance missile using infrared sensors
Participation in GMD flight test (IFT-10)	Dec. 2002	Dec. 2002	Tracked boosting target, which was launched from Vandenberg AFB, using onboard infrared sensors
ARS ground and flight test	Dec. 2002	Deferred to 3Q FY 2005	Tests of ABL tracking and ranging capabilities
BC/FC End-to-End Demonstration	Feb. 2003	Mar. 2004	First test of the fully integrated BC/FC component

(Continued From Previous Page)

Test event	Scheduled date	Completion date	Event description
“First Light”	Feb. 2003	As of Mar. 2004, new test date has not been established	First demonstration of 6-module laser operation at SIL
Full-duration laser operation	Mar. 2003	(After First Light)	Demonstration of 6-module laser operation at SIL under conditions (time and power) required for shoot-down

Source: Missile Defense Agency.

Note: Test dates current as of December 2003.

Completion of Test Milestone: Demonstration of “First Light” Continues to Slip

The Director, MDA, has made the achievement of Block 2004’s “First Light”—to prove that individual laser modules can be successfully integrated and operated to generate a single laser beam—a decisive event for the ABL program. In April 2003 testimony before the Senate Appropriations Committee, Subcommittee on Defense, the Director stated that his confidence in meeting the schedule goal for the lethality demonstration would increase tremendously if “First Light” occurred in 2003. “First Light” did not occur in February 2003 as scheduled and slipped throughout the fiscal year. As of March 2004, the test event had not been rescheduled. Numerous and continuing issues have caused the event to slip, including supply, quality, and technical problems. For example, specialized valves have been recalled twice, laser fluid management software has been delayed due to inadequate definition of requirements, and improperly cleaned plumbing and material issues have required over 3,000 hours of unplanned work. In addition, delays in hardware delivery occurred in almost every month of fiscal year 2003.

As a result of the slip in “First Light,” the program office did not exercise a contract option to acquire the Block 2008 aircraft. The office expected to exercise the option and make the first payment to the contractor, $30 million of the $170 million total, during the fourth quarter of fiscal year 2003. The remaining payments of $40 million and $100 million were scheduled for fiscal years 2004 and 2005, respectively. Because this test event continues to slip, program officials do not know when they will initiate the acquisition of the second aircraft.

Progress Assessment: Performance

Quantitative assessments of ABL effectiveness for boost-phase defense are necessarily based on end-to-end simulations of ABL operation, because the element has yet to be demonstrated in flight. At this stage of development—before the laser has been operated at full power or flown to examine the jitter issue—any assessment of element effectiveness is necessarily questionable. Nonetheless, the program office monitors performance indicators to determine whether the element is on track in meeting operational performance goals. Based on data provided to us by MDA, 9 of 12 performance indicators point to some risk in achieving Block 2004 goals. One indicator in particular, pertaining to the technology of managing "jitter," was identified as a risk item by the program office early on and continues to be monitored. This issue is discussed in more detail later in this appendix.

Progress Assessment: Cost

The cost of the ABL program continues to grow. MDA expects to invest about $3.1 billion from fiscal year 2004 through 2009 in the element's development. This is in addition to the approximately $2 billion invested from the program's initiation in 1996 through fiscal year 2003.

The program uses most of the funds it receives to fund the element's prime contract. However, in fiscal year 2003, the contractor overran its budgeted costs by $242 million.

Total Program Cost: ABL Program Costing Approximately $510 Million per Year

ABL program costs for the next 6 fiscal years are expected to be around $3.1 billion. This covers research and development efforts for Blocks 2004, 2006, and 2008. Table 17 shows the expected costs of the program by fiscal year through 2009, the last year for which MDA published its funding plans.

Table 17: ABL Planned Cost

Dollars in millions of then-year dollars

	Fiscal year						
Block	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Block 2004	$603	$474	$0	$0	$0	$0	**$1,077**
Block 2006	0	0	533	587	0	0	**1,120**
Block 2008	0	0	0	0	445	425	**870**
Total	**$603**	**$474**	**$533**	**$587**	**$445**	**$425**	**$3,067**

Source: Missile Defense Agency.

ABL costs from 1996 through fiscal year 2001 were Air Force costs that were not broken out by block but totaled a little over $1 billion. During that time, the greatest amount expended on the program in a given fiscal year was $311.4 million in fiscal year 2000.

When the ABL program transitioned to MDA in fiscal year 2002, the conversion to a more robust development program increased projected costs. The planned budget increased to approximately $465 million and $585 million in fiscal years 2002 and 2003, respectively. Program officials stated that they have also implemented a more robust developmental staff in response to numerous test failures, quality problems and complex engineering issues, all of which caused annual costs to increase after ABL's transition to MDA.

Prime Contractor Fiscal Year 2003 Cost and Schedule Performance: Significant Cost Growth and Schedule Slips

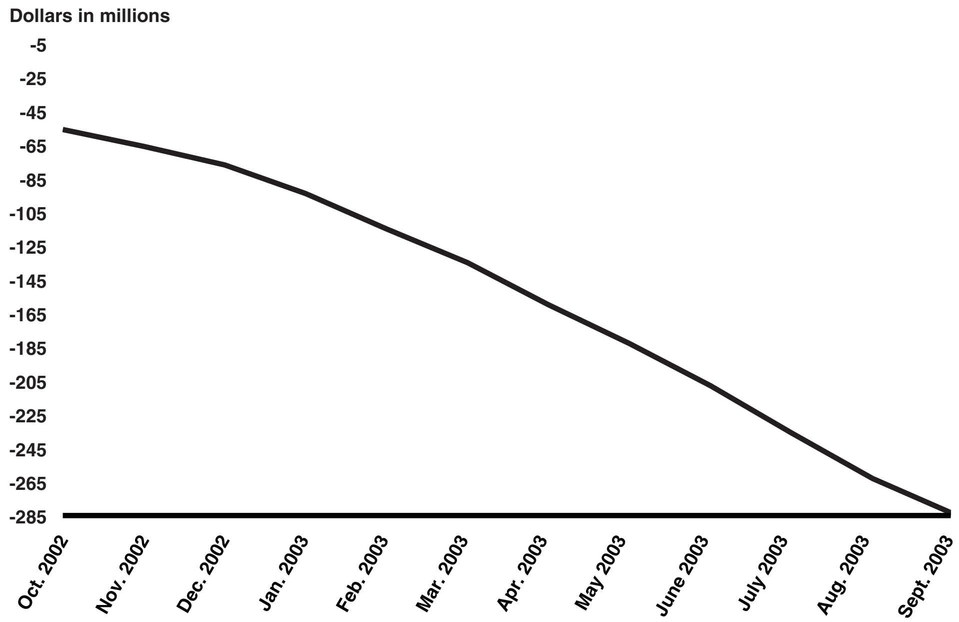
The government routinely uses contractor Cost Performance Reports to independently evaluate prime contractor performance relative to cost and schedule. Generally, the reports detail deviations in cost and schedule relative to expectations established under the contract. Contractors refer to deviations as "variances." Positive variances—activities costing less or completed ahead of schedule—are generally considered as good news and negative variances—activities costing more or falling behind schedule—as bad news.

Our analysis of contractor Cost Performance Reports indicates that ABL cost and schedule performance deteriorated throughout fiscal year 2003. In fiscal year 2003 alone, the ABL program incurred cost overruns of $242 million, which resulted primarily from integration and testing issues. Program officials indicated that it has taken longer to fabricate plumbing, install hardware, and conduct system checkouts. Furthermore, hardware that did not perform as expected and safety preparedness tended to slow down the program. In short, initial estimates of integration-related activities were substantially underestimated. Our analysis shows that these problems contributed to more than 80 percent of the overall cost overrun. The same analysis indicates that the contractor could not finish $28 million of work as planned during the same period of time.

Finally, based on the contractor's cost and schedule performance in fiscal year 2003, we estimate that the current ABL contract will overrun its budget by between $431 million and $942 million.

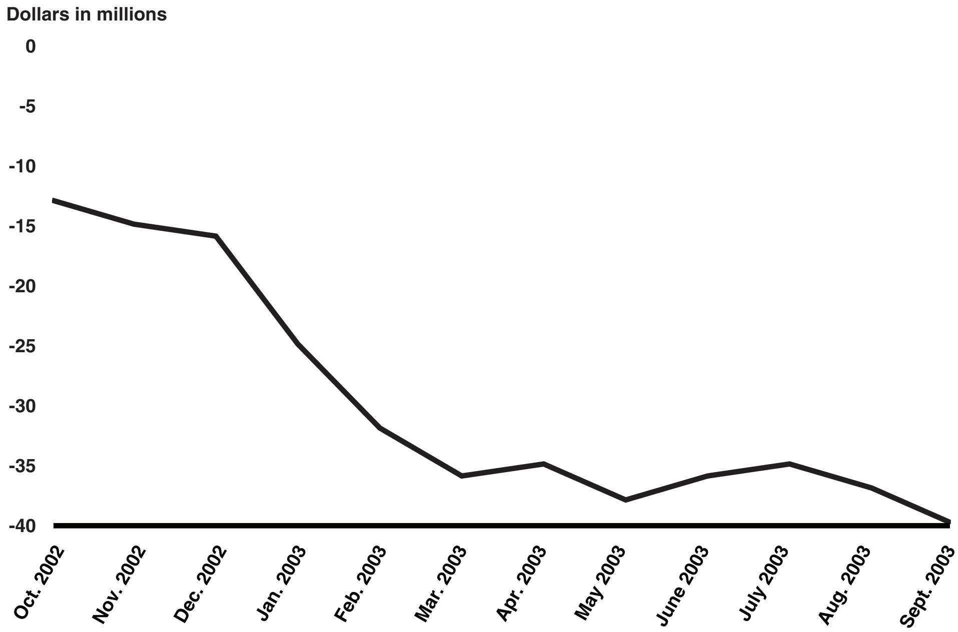
Figures 4 and 5 show the contractor's performance in fiscal year 2003. The negative variances indicate that the ABL program is exceeding its budgeted costs and is not completing scheduled work as planned.

Figure 4: Fiscal Year 2003 Cost Performance



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

Figure 5: Fiscal Year 2003 Schedule Performance



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

The element's largest contract, known as the Block 2004 prime contract, covered a period of performance from November 1996 until about 6 months after the lethal demonstration when it was awarded. However, the program office recently announced that it will close-out this contract, valued at approximately $2.2 billion, and award, in increments, follow-on contracts for the remaining Block 2004 work. The program manager told us that by awarding the remaining work in about one-year increments, the contractor should be able to establish more accurate cost and schedule estimates. In addition, the new contract structure is expected to encourage the contractor to gain knowledge from near-term tests, rather than concentrating on the longer-term goal of conducting the lethal demonstration.

Program Risks

Based on our assessment of fiscal year 2003 activities, we found that the complexity and magnitude of integration activities—to deliver a working system for the lethal shoot-down demonstration—has been substantially underestimated. Accordingly, the program continues to be at risk for cost growth and schedule slips. We also found that the uncertainty regarding the element's ability to control environmental vibration on the laser beam—jitter—is a serious performance risk for the Block 2004 program. Finally, we found that weight distribution across the airplane may be a key risk for future blocks.

Jitter as Major Performance Risk

The major performance risk for Block 2004 involves controlling and stabilizing the high-energy laser beam so that vibration unique to the aircraft environment does not degrade beam aimpoint. Reducing this so-called jitter is crucial if the laser beam is to impart enough energy on a fixed spot of the target to rupture the missile's motor casing. Currently, jitter control is developed and tested in a laboratory environment and is the least mature of ABL's critical technologies. Program officials told us that they are improving jitter analysis tools and even considering potential hardware design changes to reduce the level of vibration. They also noted that final tuning and resolution of the jitter issue would not be demonstrated before flight testing is conducted in 2005.

Weight Distribution

If future blocks require additional laser modules to increase ABL's military utility, weight distribution across the aircraft's frame may become a key issue. The program office recognizes this problem and has initiated a weight-reduction and weight-redistribution effort that includes component redesign and composite materials. The program office is also studying a possible redesign of the aircraft frame that would allow laser modules to be moved forward to relieve stress on the airframe.

Source: Missile Defense Agency

Appendix IV Summary

Command, Control, Battle Management, and Communications

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 program is working toward the delivery of a limited capability by September 2004 followed by an upgrade in defensive capabilities by the end of 2005.

The Department of Defense (DOD) budgeted about $1.3 billion for C2BMC development during fiscal years 2004 through 2009. Earlier, MDA expended $165 million in fiscal years 2002 and 2003 for element development.

Fiscal Year 2003 Progress Assessment

The C2BMC team executed the program within budget but slightly behind schedule in fiscal year 2003. Important activities, such as the completion of software testing and operator training, are continuing in fiscal year 2004 to ready the element for initial defensive operations (IDO) by September 2004.

Schedule: The C2BMC program is on track to deliver the software needed for the September 2004 defensive capability. However, the program faces a tight schedule to complete software development and testing. Other activities, such as training, also are being completed to make the system operational. The program office indicated that all such activities are on track for timely completion.

Performance: The program office predicts that key indicators of C2BMC operational performance will meet established requirements when the element comes online in September 2004. Tests, which began in September 2003, will determine if C2BMC's technical objectives are being achieved. Test results beyond fiscal year 2003 have been positive thus far.

Cost: Our analysis of the prime contractor's cost performance reports shows that the contractor completed planned work under budget but slightly behind schedule. Specifically, the contractor under-ran budgeted costs by $5.3 million in fiscal year 2003 because of a slower than anticipated increase in staffing needed for the new IDO requirements.

Key risks: The C2BMC is tracking and mitigating key BMDS-specific risks pertaining to the fielding of the initial capability by September 2004 and the Block 2004 defensive capability by December 2005. Notably, development of the C2BMC element is proceeding concurrently with the development of other elements in the BMDS. Changes in one element's design—especially in how that element interfaces with the C2BMC element—could delay C2BMC development and fielding. In addition, the BMDS concept of operations continues to evolve, leading to uncertainties about how the C2BMC element will be operated. Finally, the uncertainty regarding the reliability of communications links with the Aegis BMD element threatens to degrade overall system performance. In spite of these communications problems, the existing capability is sufficient to support IDO performance goals.

Command, Control, Battle Management, and Communications

Background: Element Description

The Command, Control, Battle Management, and Communications (C2BMC) element is being developed as the overall integrator of the Ballistic Missile Defense System (BMDS). Its objective is to tie together all system elements—such as GMD and Aegis BMD—so that system effectiveness is enhanced beyond that achieved by stand-alone systems. Unlike other system elements, C2BMC has neither a sensor nor weapon. Rather, it is primarily a software system housed in command centers or suites.[1]

The C2BMC program is working to deliver a limited operational capability in the 2004-2005 time frame. The principal function of the first increment, Block 2004, is to provide situational awareness to certain combatant commanders and others—through the dissemination of, for example, early warning data—enabling them to monitor a missile defense battle as it unfolds. It also will provide certain combatant commanders with the ability to perform missile defense planning. However, battle management functions like centralized weapons allocation—such as determining the number and timing of interceptor launches—will not be part of the Block 2004 capability but is expected to be part of future C2BMC blocks.

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

- **Command and control.** The command and control component is designed to plan, control, and monitor missile defense activities. When fielded, the command and control component provides warfighting aids needed by the command structure to formulate and implement informed decisions. In particular, the component is meant to quickly replan and adapt the element to changing mission requirements.

- **Battle management.** The role of the battle management component is to formulate and coordinate the various missile defense functions—surveillance, detection, tracking, classification, engagement, and kill

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

- assessment—needed to execute the ballistic mission defense mission. The planned battle management will direct the operation of various BMDS elements and components, consistent with pre-established rules of engagement,[2] based upon data received from system sensors.

- **Communications.** Communication is a key enabler for the integration of the BMDS. The objective of systems communications is to manage and achieve the dissemination of information necessary to perform the battle management and command and control objectives.

The C2BMC program is following the MDA capability-based acquisition approach that emphasizes testing, spiral development, and evolutionary acquisition through the use of 2-year capability blocks. Within these blocks, MDA expects to evolve the C2BMC element through a series of software upgrades known as "spirals," each of which increases the element's capability to perform the ballistic missile defense mission.

Background: History

MDA initiated the C2BMC program in 2002 as a new element of the BMDS. Program officials indicated that Block 2004 C2BMC software is based on the Air Force's Combatant Commander's Integrated Command and Control System, the Air Force's Joint Defensive Planner software, and GMD-developed fire control (battle management) software.

Background: Developmental Phases

C2BMC development efforts are aligned according to Block 2004, Block 2006, and beyond.

Block 2004. The Block 2004 defensive capability is being rolled out in two phases: initial defensive operations (IDO) and the Block 2004 defensive capability. By September 2004 when IDO is available, C2BMC will provide situational awareness, planning capabilities, and communications "backbone" to allow warfighters to monitor the ballistic missile defense battle. The software build associated with IDO's defensive capability is referred to as "Spiral 4.3." MDA is working with combatant commanders to

[2] Rules of engagements are directives that delineate the circumstances and limitations under which U.S. forces will initiate and/or continue combat engagement with other forces encountered.

define the capabilities of "Spiral 4.5"—the final version of the Block 2004 defensive capability that is expected to be fielded by December 2005—which will be an enhancement of the IDO C2BMC capability defined by Spiral 4.3. MDA is also activating C2BMC suites at U.S. Strategic Command (USSTRATCOM), U.S. Northern Command (USNORTHCOM),[3] U.S. Pacific Command (USPACOM), and other locations including the National Capital Region.

Block 2006. The incorporation of battle management capabilities in the C2BMC element begins with Block 2006. The element will provide real-time battle management to fuse available sensor information, track the threat throughout its entire trajectory, and select the appropriate elements to engage the threat. For example, the C2BMC battle manager may use radars across multiple elements to generate a single track of the threat and direct GMD to launch interceptors. Additional C2BMC sites will also be activated during this time frame.

C2BMC's long-term objective is to tie all BMDS elements and sensors into a distributed, worldwide, integrated, and layered missile defense system.

Progress Assessment: Schedule

The C2BMC program deputy director indicated that the program is on schedule to meet IDO and Block 2004 expectations, that is, to have the BMDS on alert by the end of September 2004 for IDO and upgraded by the end of December 2005. To achieve this goal, the C2BMC element is

- developing, testing, and verifying Block 2004 C2BMC software (Software delivery);
- integrating the C2BMC element into the BMDS and incorporating communications upgrades; and
- making the BMDS operational, including warfighter Concept of Operations (CONOPS),[4] warfighter training, and activating C2BMC sites.

[3] The USNORTHCOM suite is situated at the Joint National Integration Center (JNIC), located at Schriever Air Force Base, Colorado.

[4] CONOPS is a broad outline of the manner in which a commander operates a weapon system.

C2BMC Software Delivery: IDO Software Development Completed, but Testing and Verification Continues

Table 18 summarizes the principal activities pertaining to the development and testing of the first three spirals of Block 2004 C2BMC element software. The development of Spiral 4.3 in nearly completed, and BMDS-level testing (Cycle-3 testing[5] and Cycle-4 testing[6]) of this spiral will be conducted to some extent before IDO, e.g., during GMD integrated flight tests and war games.

Table 18: Block 2004 C2BMC Activities—Develop, Test, Verify Software

Software build	Activity	Actual/Anticipated completion date	Comments
Spiral 4.1	Development	Mar. 2003	Development and testing completed. Functional and performance testing successful. Spiral 4.1 will be used in Missile Defense Integration Exercise 03 for verification.[a]
	Testing	Oct. 2003	
Spiral 4.2	Development	Sept. 2003	Development of Spiral 4.2 completed and delivered for system testing. Spiral 4.2 expected to be used in Integrated Missile Defense War Game 03-2 and Missile Defense Integration Exercise 04a for verification.[b]
	Testing	Jan. 2004 (Cycle 3)	
Spiral 4.3	Development	May 2004	Block 2004 (IDO Focus) Capability Specification delivered. "Build Plan" and "Spiral Content Agreement" completed.
	Testing	July 2004 (Cycle 3)	
		Dec. 2004 (Cycle 4)	

Source: Missile Defense Agency.

[a]Missile Defense Integration Exercise: Conducted to characterize the degree of integration and interoperability between BMDS elements to operate as a single system.

[b]Integrated Missile Defense War Game: Conducted to allow the User community to gain insight and provide feedback on operational issues

The program's Spiral Engineering Team has not fully defined the capabilities planned for Spirals 4.4 and 4.5, the software builds leading up to the Block 2004 defensive capability of December 2005. The team expects

[5] Cycle-3 testing: Third of four cycles of testing to verify that C2BMC interfaces with each BMDS element individually.

[6] Cycle-4 testing: Fourth of four cycles of testing to verify system-level integration. During Cycle 4 testing, the C2BMC element participates in flight tests planned and conducted by MDA.

to complete the definitions of the Spirals 4.4 and 4.5 in March 2004 and July 2004, respectively.

Communications and Integration: Activities Completed as Planned

The C2BMC element is upgrading existing communications systems and developing capabilities to allow all BMDS components to exchange data, including command and control orders. Table 19 summarizes the principal activities completed in fiscal year 2003 pertaining to C2BMC's role in system integration and communications. These activities were generally completed on time.

Table 19: Block 2004 C2BMC Activities—Communications and Integration

Activity	Date completed
Approval of Block 2004 Network Design	Nov. 2002
Completion of Block 2004 Communications Network baseline	June 2003
Approval of all element Interface Control Specifications[a]	June 2003
Successful demonstration of initial Aegis—Regional Gateway—C2BMC connectivity	July 2003
Completion of draft C2BMC—GMD Element Interface Description Document[b]	Aug. 2003
Completion of draft C2BMC—Aegis BMD Element Interface Description Document	Feb. 2004

Source: Missile Defense Agency.

[a]An element Interface Control Specification between the C2BMC suite and external elements defines the functional, informational, and physical requirements for the interfaces between the C2BMC suite and that part of the external element interface adapted to establish message passing and protocol compatibility between two elements.

[b]The Element Interface Description Document is developed to provide the detail needed to support implementation of the interface between the C2BMC and a given element

Operational Capability: Program Taking Steps to Make BMDS Operational

A variety of activities needed if the C2BMC is to deliver an operational BMDS have been completed or are ongoing. These activities include site activation, which is required before the C2BMC suites are built; the warfighter developing a CONOPS; and training military operators for conducting ballistic missile defense missions.

- **Site activation.** Full site surveys have been conducted, site installation plans have been signed, and equipment has been ordered for USSTRATCOM, USNORTHCOM, and USPACOM. This also has been done for one National Capital Region site. Equipment installation will begin at the end of March 2004 and continue throughout the summer.

- **CONOPS.** A conference to write a CONOPS was held in November 2003.

- **Training.** Full operator training is scheduled to begin at USNORTHCOM in June 2004, USSTRATCOM in June 2004, and USPACOM in July 2004. Training for the National Capital Region site is also expected to begin in July 2004. Part of the system-level training is participation in Integrated Missile Defense War Games.

Progress Assessment: Performance

Spiral tests for each software build will determine if C2BMC's technical objectives are being achieved. These tests are expected to indicate if the program needs to make adjustments, such as adding personnel to work on identified problems. The program office predicts, and planned fiscal year 2004 testing is expected to verify, that all top-level C2BMC performance indicators will meet operational performance goals when the IDO capability comes online in September 2004.

Progress Assessment: Cost

MDA expects to invest about $1.3 billion from fiscal year 2004 through 2009 in the development and enhancement of the C2BMC element. This is in addition to the $165.4 million expended in fiscal years 2002 and 2003.

The program uses most of the funds it receives to fund the element's prime contract. During fiscal year 2003, the contractor completed planned work slightly behind schedule, but the work cost less than projected.

Total Program Cost: C2BMC Program Costing Approximately $220 Million per Year

The C2BMC program's planned costs for the next 6 fiscal years are expected to be around $1.3 billion. This includes costs for Blocks 2004, 2006, and Block 2008. In addition, the program expended $68.0 million and $97.4 million in fiscal years 2002 and 2003, respectively. Table 20 shows expected C2BMC program costs by fiscal year through 2009, the last year for which MDA published its funding plans.

Table 20: C2BMC Planned Cost

Dollars in millions of then-year dollars

	Fiscal year						
Block	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Block 2004	$116.5	$154.0	$0	$0	$0	$0	**$270.5**
Block 2006	26.7	58.2	186.4	200.1	0	0	**471.4**
Block 2008	0.4	10.8	33.9	40.4	242.7	246.3	**574.5**
Total	**$143.6**	**$223.0**	**$220.3**	**$240.5**	**$242.7**	**$246.3**	**$1,316.4**

Source: Missile Defense Agency.

Prime Contractor Fiscal Year 2003 Cost and Schedule Performance: Efficient

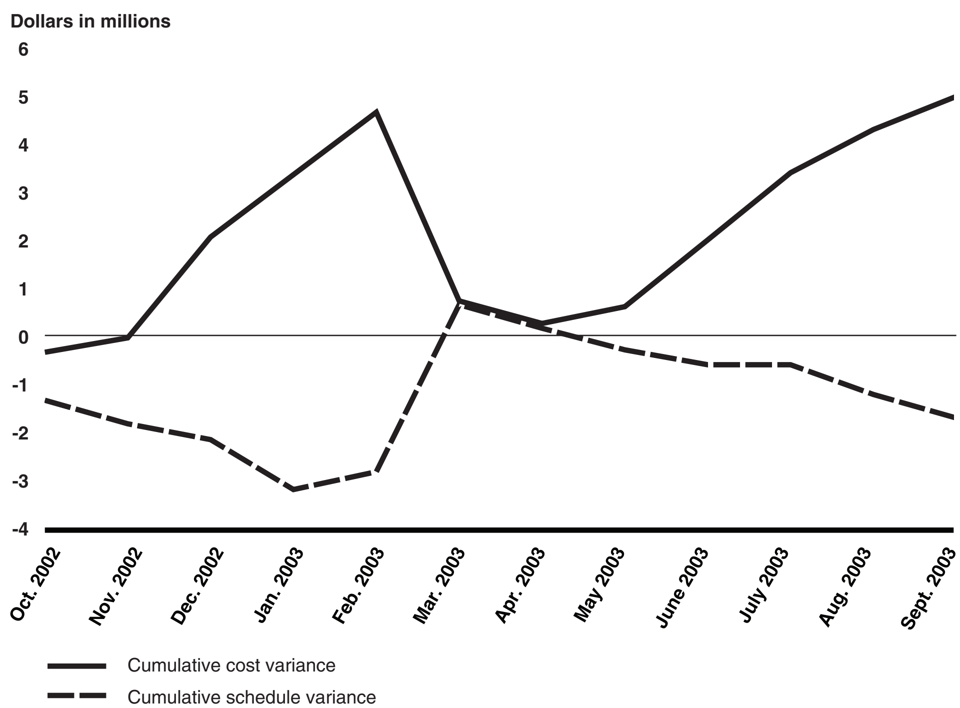
The prime contract consumes the bulk of the program's budget: about 97 percent of the Block 2004 budget supports the prime contractor team and 3 percent supports government efforts. The prime contract is an Other Transaction Agreement (OTA),[7] which functions much like a prime contract. Through an OTA, the C2BMC element is able to take advantage of more collaborative relationships between industry, the government, Federally Funded Research and Development Centers, and University Affiliated Research Centers. The C2BMC Missile Defense National Team (MDNT), for which Lockheed Martin Mission Systems 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 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—activities costing less or completed ahead of schedule—are generally considered as good news and negative variances—activities costing more or falling behind schedule—as bad news.

[7] An OTA refers to transactions other than contracts, grants, or cooperative agreements that are entered into under the authority of 10 U.S.C. § 2371 (2000 & Supp. I 2001) in carrying out 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 carrying out prototype projects. OTAs generally are not subject to federal laws and regulations applicable to procurement contracts.

In fiscal year 2003, the program expended $97.4 million for all efforts associated with the development of the C2BMC element. Our analysis of contractor Cost Performance Reports indicates that C2BMC's efforts are being completed with "cost efficiency." That is, C2BMC work is costing slightly less than estimated. Specifically, there was a $5.3 million cost under-run incurred during fiscal year 2003. (See figure 6.) During this time, the contract also had an average cumulative Cost Performance Index of 1.04, meaning that for every budgeted dollar spent to accomplish scheduled work, the contractor actually completed $1.04 worth of scheduled work.

Figure 6: Fiscal Year 2003 Cost and Schedule Performance



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

However, contractor Cost Performance Reports showed that work is slightly behind schedule. According to program officials, understaffing is the primary reason for any schedule delays. The combination of a government-directed hiring slowdown and the limited numbers of highly qualified personnel in the areas of command, control, battle management, and communications available to work on the program resulted in a slower than anticipated increase in staffing.

To ensure that information reported in Cost Performance Reports can be relied upon, programs generally conduct Integrated Baseline Reviews of the prime contract. The review verifies that the contractor's performance measurement baseline,[8] against which the contractor measures its cost and schedule performance, includes the work directed by the contract. It also verifies that the budget and schedule attached to each work task are accurate, that contractor personnel understand the work task and have been adequately trained to make performance measurements, and it ensures that risks have been properly identified. According to DOD guidance, a review should be conducted within 6 months of the award of a new contract or major change to an existing contract.

Although our analysis of C2BMC Cost Performance Reports has not shown any significant cost or schedule variances, an Integrated Baseline Review was not conducted for the Other Transaction Agreement on which we reported the contractor's cost and schedule performance. According to C2BMC contract officials, the technical baseline was re-established, and budgets and schedules were realigned to reflect changes in mission priorities, namely, to have the element ready and available for IDO. Integrated Baseline Reviews are planned for the future.

Program Risks

The C2BMC is tracking and mitigating key BMDS-specific risks pertaining to the fielding of the initial capability by September 2004 and the Block 2004 defensive capability by December 2005. These risks pertain to the integration of C2BMC with other system elements, the continuing evolution of the BMDS CONOPS, and the unreliability of a communications link for the Aegis BMD element.

Integration

Development of the C2BMC element is proceeding concurrently with the development of other system elements, such as GMD and Aegis BMD. Changes in one element's design, especially with how it interfaces with 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.

C2BMC element, could result in temporary incompatibilities during Block 2004 integration. The potential consequences include delays in C2BMC development and fielding, increased costs, and reduced software quality. The program office is tracking this item as a key BMDS-level risk and devoting resources to prevent the realization of integration incompatibilities.

Evolving CONOPS

Changes in the roles and responsibilities of combatant commanders for the missile defense mission are leading to uncertainties in the BMDS concept of operations. This affects how the warfighter prepares, through training and other procedures, to operate the C2BMC element once it becomes operational. The C2BMC program office acknowledges this risk and has efforts under way to address it. For example, the office is actively engaging military users in exercises and war games to provide the users with an opportunity to recognize their needs in an operational environment so that they may better define CONOPS requirements.

Communications

Uncertainty regarding the reliability of communications links with the Aegis BMD element, a system-level risk tracked by the C2BMC program office, threatens to degrade overall system performance. Nonetheless, program officials told us that the existing capability is sufficient to support IDO performance goals and that MDA plans to enhance Block 2004's performance by upgrading existing communication components.[9]

[9] Additional details are provided in a classified annex to this report.


Source: Missile Defense Agency

Appendix V Summary

Ground-based Midcourse Defense

Program Description

The Ground-based Midcourse Defense (GMD) element is a missile defense system being developed to protect the United States against long-range ballistic missile attacks. During the 2004-2005 time frame, the GMD program office plans to deliver an operational capability that provides protection against limited ballistic missiles attacks from Northeast Asia and the Middle East.

The GMD program is expected to deliver an initial capability by the end of September 2004, which is known as Initial Defensive Operations (IDO). By the end of calendar year 2005, MDA plans to have augmented the IDO capability with additional interceptors and radars.

The Department of Defense (DOD) budgeted about $12.9 billion for GMD's development and fielding during fiscal years 2004 through 2009. Earlier, DOD expended about $12.4 billion between fiscal years 1996 and 2003 for related research and development.

Fiscal Year 2003 Progress Assessment

The GMD program completed many planned activities that are expected to lead to the September 2004 initial capability known as IDO. The delay in the development and delivery of GMD interceptors, however, has caused flight tests (intercept attempts) leading to IDO to slip 10 months. These problems also resulted in the growth of program costs.

Schedule: Site preparation, including construction of missile silos and facilities at Fort Greely, Alaska, and Vandenberg Air Force Base, California, is on schedule. Activities to upgrade existing radars are also on track. However, the program has been challenged by developmental and production issues with the interceptor—comprising a booster and kill vehicle—and will not meet MDA's upper-end goal of delivering and fielding 10 interceptors by September 2004.

Performance: GMD has demonstrated the ability to destroy target warheads through "hit-to-kill" intercepts in past flight tests. These flight tests, however, were developmental in nature—the element has yet to be tested under operationally realistic conditions. Moreover, as noted above, the flight test program leading up to IDO has been compressed. As a result, MDA has a limited opportunity to characterize GMD's performance before initial fielding. Nonetheless, the program office contends that GMD is on track to meet operational performance goals.

Cost: Our analysis of the prime contractor's cost performance reports shows that the contractor overran its budgeted costs in fiscal year 2003 by $138 million and was unable to complete $51 million worth of scheduled work. Developmental issues with the interceptor's booster and kill vehicle have been the leading cause of cost overruns and schedule slips; for example, the interceptor's development cost $127 million more in fiscal year 2003 than the contractor budgeted.

Risks: GMD faces significant testing and performance risks, which are exacerbated by an optimistic schedule to meet the September 2004 deadline for fielding the initial capability. Specifically, delays in flight testing have left the program with only limited opportunities to demonstrate the performance of fielded components and to resolve any problems uncovered during flight testing prior to September 2004. Uncertainty with the readiness of interceptor production could prevent MDA from meeting its program goal of fielding 20 interceptors by the end of 2005. Finally, an unresolved technical issue with the kill vehicle adds uncertainty to the element's performance.

Ground-based Midcourse Defense

Background: Element Description

The Ground-based Midcourse Defense (GMD) program expects to deliver an operational capability in the 2004-2005 time frame as an interoperable element of the Ballistic Missile Defense System (BMDS). The first increment of the GMD element, known as Block 2004, is being fielded in two major phases:

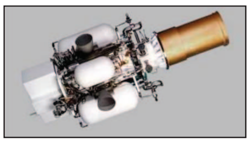
- **Initial Defensive Operations (IDO).** GMD is expected to deliver an initial capability by the end of September 2004. The principal components include a maximum of 10 interceptors (6 at Fort Greely, Alaska, and 4 at Vandenberg Air Force Base, California); GMD fire control nodes for battle management and execution at Fort Greely and Schriever Air Force Base, Colorado; an upgraded Cobra Dane radar at Eareckson Air Station, Alaska; and an upgraded early-warning radar at Beale Air Force Base, California. With this initial capability, MDA expects to provide the United States with protection against a limited ballistic missile attack launched from Northeast Asia.

- **Block 2004 Defensive Capability.** By the end of calendar year 2005, MDA plans to augment the IDO capability by installing additional interceptors at Fort Greely and Vandenberg Air Force Base (for a total of 20), deploying a sea-based X-band radar, and upgrading the early-warning radar at Fylingdales, England. These enhancements are expected to provide additional protection from intercontinental ballistic missiles (ICBMs) launched from the Middle East.

Figure 7 illustrates the Block 2004 GMD components, which are situated at several locations within and outside of the United States.

Figure 7: GMD Element

Interceptor booster



Exoatmospheric kill vehicle

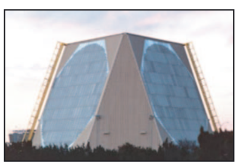
Mission: The interceptor consists of a silo-based, three-stage booster stack and “hit-to-kill” exoatmospheric kill vehicle. The kill vehicle is the weapon component of the interceptor that attempts to detect and destroy the threat through a hit-to-kill impact.

Location: Missile fields in Ft. Greely, Alaska, and Vandenberg Air Force Base, California.

Fire control and communications

Mission: The fire control (battle management) component is the integrating and controlling entity of the GMD element. Its software plans engagements and tasks GMD components to execute a mission. The in-flight interceptor communications system enables the fire control component to communicate with the kill vehicle while in flight.

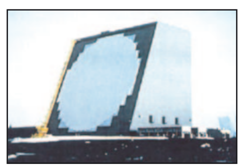
Location: Fire control node, Schriever Air Force Base, Colorado.



Upgraded early warning radars

Mission: Upgraded early warning radars for midcourse tracking in support of the GMD mission.

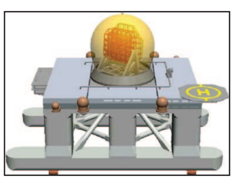
Location: Beale Air Force Base, California; Flyingdales, England.



Cobra Dane radar

Mission: Principal fire control radar for tracking missiles launched out of northeast Asia.

Location: Eareckson Air Station, Alaska.



Sea-based X-band radar

Mission: X-band radar emplaced on a sea-based, mobile platform in the Pacific. It will not be fielded with the initial defensive capability in September 2004 but will be available in late 2005 for use in flight testing or as an operational asset for midcourse tracking and discrimination.

Location: Pacific Ocean.

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

Background: History

The GMD element can be traced back to the mid-1980s, when the Department of Defense (DOD) conducted experiments designed to demonstrate the feasibility of employing hit-to-kill technology—the ability to destroy a missile through a direct collision—for missile defense. During the early 1990s, a technology readiness program continued the development of interceptor technology. These efforts culminated in the establishment of the National Missile Defense (NMD) program in 1996 to develop and field a national missile defense system as a major defense acquisition program.

The NMD program office's mission was to develop a system that could protect the United States from ICBM attacks and to be in a position to deploy the system by 2005,[1] if the threat warranted. The system was to consist of space- and ground-based sensors, early-warning radars, hit-to-kill interceptors, and battle management components. The current GMD program is based directly on research and development conducted by the NMD program. GMD is now one "element" of the overarching BMDS, which is funded and managed by the Missile Defense Agency (MDA).

Background: Developmental Phases

GMD's development and fielding are proceeding in a series of planned 2-year blocks. The near-term blocks are known as Blocks 2004 and 2006. The developmental efforts of each block incrementally increase element capability by maturing the hardware's design and upgrading software.

Block 2004. During Block 2004, MDA expects to field a basic hit-to-kill capability that can be enhanced in later blocks. Originally, the program's Block 2004 focus was on development and testing. However, the December 2002 directive by the President to begin fielding a missile defense system in 2004 affected the program's Block 2004 direction. According to program office officials, this change resulted in GMD's shifting to a more production-oriented program, accelerating activities to make the element operational.

Block 2006. Block 2006 is focused on improving and enhancing the Block 2004 GMD capability. The program expects to improve existing capabilities, field additional interceptors, and conduct tests to demonstrate performance against more complex missile threats and environments. It

[1] An initial operational capability (IOC) was scheduled for the end of fiscal year 2005.

also expects to upgrade the early-warning radar located at Thule Airbase, Greenland, for expanded sensor coverage.

Progress Assessment: Schedule

The GMD program completed many of the activities planned for fiscal year 2003. For example, the program accomplished non-technical activities such as site preparation and facility construction at many locations, especially at Fort Greely, on or ahead of schedule. Similarly, activities leading to the development and delivery of the element's battle management component and of radars that the element depends upon to detect and track targets were generally completed on schedule. However, delays in the development and delivery of the GMD interceptor—particularly due to one of its two boosters—caused intercept attempts leading up to IDO to slip 10 months or more.

Construction of GMD Element Facilities: on Track to Support Initial Deployment

Many of the GMD activities completed in fiscal year 2003 pertain to the construction of infrastructure—missile silos, buildings, and other facilities—at GMD's various sites. The largest construction effort is at Fort Greely, where missile silos and supporting facilities are being built. Additional construction activities are occurring at Eareckson Air Base and at Vandenberg Air Force Base (AFB), where four missile silos are being modified. According to MDA, all construction activities are on or ahead of schedule. Table 21 summarizes the major construction activities undertaken in fiscal year 2003 and their estimated completion dates.

Table 21: Progress of Major GMD Construction Projects

Activity	Location	Completion date	Status
Interceptor Silo Construction/Modification	Fort Greely	Feb. 2004	Completed
	Vandenberg AFB	Apr. 2004	On schedule
Readiness and Control Building	Fort Greely	Nov. 2003	Completed
Mechanical Electrical Building	Fort Greely	July 2003	Completed
Power Plant Upgrade	Fort Greely	Oct. 2003	Completed
Entry Control Station	Fort Greely	Nov. 2003	Completed
Missile Assembly Building	Fort Greely	Jan. 2004	Completed
Perimeter Security	Fort Greely	Mar. 2004	Completed

Source: Missile Defense Agency.

GMD Component Development: Progress Made, but Interceptor Development Is Problematic

In fiscal year 2003, the GMD program focused on the development of its Block 2004 components: (1) GMD fire control nodes and communications network, (2) upgraded early-warning radars, (3) Cobra Dane radar, (4) sea-based X-band radar, and (5) ground-based interceptors. Many of the activities planned for fiscal year 2003, such as hardware delivery, did not culminate in 2003. Rather, the completion dates are scheduled in fiscal years 2004 or 2005 to coincide with the start of defensive operations.

GMD Fire Control Component: Development on Track

The fire control component[2] 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 interceptor, 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.

According to contractor reports, the GMD fire control component effort is proceeding on schedule and is expected to be ready for IDO. For example, the installation of equipment for the communication networks and the fire control nodes are on schedule. Additionally, the program completed the installation of a fiber optic ring—the so-called CONUS[3] Ring—that connects all the command, control, and communication networks of the GMD element.

Upgraded Early Warning Radars: Development on Track

The early warning radar is an upgraded version of existing UHF-band 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.

Fiscal year 2003 activities related to upgrading the early warning radar at Beale AFB included

- developing and testing software;

[2] The fire control component has historically been referred to as the command and control, battle management, and communications (BMC3) component of the GMD element.

[3] CONUS is the acronym for "Continental United States."

- acquiring radar hardware and data processors;
- completing the design of and constructing the Beale facility; and
- supporting flight, ground, and radar certification tests.

According to program office documentation, the completion of the Beale upgrade is on track for meeting the September 2004 IDO date, even though software development fell behind schedule in fiscal year 2003. Program officials stated that they have not yet begun upgrading the early warning radar at Fylingdales, which they expect to complete by December 2005.

Cobra Dane Radar: Development On Track

The Cobra Dane radar, located at Eareckson Air Station on Shemya Island, Alaska, is currently being used to collect data on ICBM test launches out of Russia. Cobra Dane's surveillance mission does not require real-time communications and data-processing capabilities; therefore, it is being upgraded to be capable of performing the missile defense mission as part of the Block 2004 architecture. Once upgraded, Cobra Dane is expected to operate much like the upgraded early warning radar at Beale AFB. Although its hardware needs only minor improvement, 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 communication functions.

In fiscal year 2003, the GMD program

- began hardware installation,
- completed software development—testing is continuing, and
- finished the modification of the Cobra Dane facility.

In general, the program made significant progress in upgrading the Cobra Dane radar during fiscal year 2003. According to program office documentation and our analysis of GMD's master schedule, Cobra Dane is on track for meeting the September 2004 IDO date.

Sea-Based X-Band Radar: Development on Track

The GMD program office is managing the development of a sea-based X-band radar (SBX) to be delivered and first tested by the end of Block 2004. SBX will consist of an X-band radar—much like the one located at Reagan Test Site that has been used in past flight tests—

positioned on a sea-based platform, similar to those used for offshore oil drilling. The radar is designed to track enemy missiles with high accuracy; discriminate warheads from decoys and other objects; and if the intercept occurs within SBX coverage, assess whether it was successful.

In fiscal year 2003, MDA initiated the acquisition of various SBX components, including the sea platform, operations and support equipment for the platform, the radar structure, and electronic components. In addition, design and development have continued on the X-Band radar to be positioned on the platform. MDA program officials stated that the SBX will be fielded as a test asset by the end of Block 2004 (December 2005), and MDA budget documentation indicates that it will be placed on alert as an operational asset during Block 2006. Modification of the platform and production of the SBX antenna is on schedule, and electronics production is ahead of schedule.

Ground-Based Interceptor: Development and Production Issues Delay GMD Program

The ground-based interceptor—the weapon component of the GMD element—consists of a kill vehicle[4] 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 to detect, track, and steer itself into the enemy warhead, destroying it above the atmosphere through a hit-to-kill collision.

In fiscal year 2003, the program focused on the development and testing of boosters that will be produced for flight tests, IDO, and the Block 2004 inventory. Booster development actually began in 1998, but because of difficulty encountered by the prime contractor, MDA adopted a dual-booster approach as part of a risk reduction strategy. The development of the booster was transferred to Lockheed Martin, which is developing a variant of the original booster. The variant is referred to as "BV+." MDA also authorized the GMD prime contractor to award Orbital Sciences Corporation (OSC) a contract to produce a second booster that is known as the "OSC booster."

On the basis of our review of fiscal year 2003 activities, booster development and production represent major challenges for the GMD program in meeting its Block 2004 goals, as shown below:

[4] The GMD program refers to its kill vehicle as the "exoatmospheric kill vehicle" (EKV).

- **Technical.** For the most part, the OSC booster has not experienced technical issues preventing it from being tested and produced. However, the BV+ booster has had problems with its first stage attitude control system. In addition, GMD program officials stated that the BV+ booster is experiencing quality-related problems with its flight computers.

- **Testing.** The OSC booster successfully demonstrated the performance needed for the GMD mission through a series of flight tests.[5] Beginning with integrated flight test 14, which is scheduled for 4Q FY 2004,[6] the OSC booster will be used in all intercept attempts for the remainder of Block 2004. The Lockheed BV+ booster, however, was flight tested in its new configuration in January 2004 after an 11-month slip. According to MDA officials, its use in flight testing and fielding has been deferred to the end of fiscal year 2005.

- **Production.** Because delayed test events are often indicative of development problems, these delays increase the uncertainty of whether the contractors will be able to meet their production goals for IDO and Block 2004. Additionally, accidents at a subcontractor's facility have jeopardized the delivery of Lockheed BV+ boosters for GMD's initial deployment. The production facility responsible for propellant mixing for the BV+ upper-stage motors was temporarily shut down following two separate explosions. As a result, MDA is accelerating the production of OSC boosters to compensate for the undelivered Lockheed BV+ boosters. It is unclear, however, whether OSC has the capacity to produce the additional boosters necessary for IDO.

Kill vehicle development is proceeding in parallel with development of the boosters. In fiscal year 2003, the program focused on developing and producing kill vehicles for flight tests scheduled in fiscal year 2004. Similar production-representative articles will be deployed as part of the IDO and the Block 2004 defensive capability. Kill vehicle development and production, however, represent challenges for the GMD program in meeting its Block 2004 goals. For example, the contractor has yet to demonstrate that it can increase the production rate of kill vehicles by 50 percent.

[5] Booster performance was demonstrated in booster validation (BV) test "BV-6" and in integrated flight test "IFT-13B."

[6] We use the notation "4Q FY 2004" to mean the fourth quarter of fiscal year 2004 and an identical format for other time periods.

As a result of developmental and production issues with the kill vehicle and boosters, the GMD program likely will not be able to meet its goal of delivering 20 interceptors required for the Block 2004 inventory or its upper-end goal of delivering 10 interceptors for IDO. Program documentation indicates that 5, rather than 10, interceptors will be fielded when IDO is declared at the end of September 2004; MDA expects that it will not have 10 interceptors until February 2005. MDA officials did not provide us with a schedule of interceptor deliveries for the remaining 10 interceptors that are to be fielded by the end of Block 2004 (December 2005).

GMD Testing: Flight Test Program Plagued with Schedule Slips

The GMD program conducts a variety of tests, the most visible being flight test events. Flight tests may be conducted at the component level. For example, the program has planned and conducted booster validation (BV) flight tests to ensure proper operation of GMD's two booster designs. However, integrated flight tests[7] (IFTs) are most reflective of the environment in which the various components will be required to operate as an integrated element.

During fiscal year 2003, the GMD program office conducted four flight test events: IFT-9, IFT-10, a demonstration flight of the OSC Taurus missile, and one of two booster validation tests (BV-6). A summary of information pertaining to these key flight test events is provided in table 22.

[7] Integrated flight tests are real-world demonstrations of the GMD element. During an intercept attempt, an interceptor is launched to engage and intercept a mock warhead above the atmosphere.

Table 22: GMD Flight and Booster Tests, Fiscal Year 2003

Test event	Date	Description	Outcome
IFT-9	Oct. 14, 2002	Intercept attempt as part of an integrated flight test	Successful intercept
IFT-10	Dec. 15, 2002	Intercept attempt as part of an integrated flight test	Failed intercept attempt—kill vehicle did not separate from surrogate booster
OSC demo	Feb. 6, 2003	Demonstration of OSC Taurus missile (precursor to OSC boost vehicle)	Successful demonstration—all objectives achieved
BV-6	Aug. 16, 2003	Demonstration of OSC boost vehicle of the configuration to be fielded	Successful demonstration—all objectives achieved

Source: Missile Defense Agency.

Of the two intercept tests conducted (IFT-9 and IFT-10), IFT-9 succeeded in intercepting the target while IFT-10 did not. Additionally, both OSC booster tests (OSC demo and BV-6) achieved their booster-related objectives. The table, however, does not reflect the extent of delays on the entire GMD flight test program caused by fiscal year 2003 developmental and delivery issues of the interceptor. As shown in table 23 below, the Block 2004 flight test program leading up to IDO (September 2004)—consisting of booster validation tests and integrated flight tests—has slipped throughout fiscal years 2003 and 2004. As a result, the test schedule leading up to IDO has become compressed. Indeed, the last integrated flight test to be conducted before IDO is declared, IFT-14, is scheduled to occur 1-2 months before this date; originally, the program had scheduled IFT-14 to occur 12 months before IDO and IFT-15 to occur 10 months before IDO. As a result, MDA has limited its opportunity to validate models and simulations of the interceptor's expected performance, which, in turn, reduces its ability to confidently characterize GMD's performance prior to the initial fielding.

Table 23: Block 2004 Flight Test Program Leading to IDO—Schedule Delays

Test event	Original date	Actual/Updated date	Delay (months)
Completed test events			
IFT-9 (intercept attempt)	Aug. 2002	Oct. 14, 2002	2
IFT-10 (intercept attempt)	Dec. 15, 2002	Dec. 11, 2002	0
OSC Demo	Jan. 31, 2003	Feb. 6, 2003	0
BV-6 (OSC booster test)	Apr. 30, 2003	Aug. 16, 2003	3.5

(Continued From Previous Page)

Test event	Original date	Actual/Updated date	Delay (months)
BV-5 (BV+ booster test)	Feb. 20, 2003	Jan. 9, 2004	11
IFT-13B (OSC booster test)	July 15, 2003	Jan. 26, 2004	6
Scheduled test events			
IFT-13A (BV+ booster test)	May 2003	4Q FY 2005[a]	26+
IFT-13C (Kill vehicle fly-by)	Mar. 2004	3Q FY 2004	3
IFT-14 (intercept attempt)	Oct. 2003	4Q FY 2004	10
IFT-15 (intercept attempt)	Dec. 2003	FY 2005 (schedule being reassessed)	10+

Source: Missile Defense Agency.

Note: Test schedule as of April 2004.

[a]We use the notation “4Q FY 2005” to mean the fourth quarter of fiscal year 2005 and an identical format for other time periods.

Progress Assessment: Performance

Operational Performance of GMD Remains Uncertain

The GMD program, which is the primary portion of the Block 2004 defensive capability, has demonstrated the capability to intercept target warheads in flight tests since 1999. In fact, the program has achieved five successful intercepts out of eight attempts. However, because of range limitations, these flight tests were developmental in nature, and engagement conditions were limited to those with low closing velocities and short interceptor fly-out ranges.

As noted in our recent report, none of the GMD components included in the initial defensive capability have been flight tested in their fielded configuration (i.e., with production-representative software and hardware).[8] For example, the GMD interceptor—booster and kill vehicle—will not be tested in its Block 2004 configuration until the next intercept attempt, IFT-14, which the GMD program office plans to conduct in 4Q FY 2004. IFT-14 will also test, for the first time, battle management software that will be part of the September 2004 defensive capability. Finally, MDA

[8] U.S. General Accounting Office, *Missile Defense: Actions Being Taken to Address Testing Recommendations, but Updated Assessment Needed*, GAO-04-254 (Washington, D.C.: February 2004).

does not plan to demonstrate the operation of the critical GMD radar, called Cobra Dane, in flight tests before IDO. Therefore, as noted in the Director, Operational Test and Evaluation (DOT&E) Fiscal Year 2003 Annual Report to Congress, assessments of operational effectiveness will be based on theoretical performance characteristics. Nonetheless, the program office told us that performance indicators predict that GMD is on track to meet operational performance goals.

Progress Assessment: Cost

DOD budgeted about $12.8 billion during fiscal years 2004 through 2009 for research, development, and fielding of the GMD element. This is in addition to the $12.4 billion already expended between fiscal years 1996 and 2003.

Most of the program's budget is allocated to fund the element's prime contract. In fiscal year 2003, the contractor overran its budgeted costs by $138 million and was unable to complete $51 million worth of work.

Total Program Cost: GMD Program Costing Approximately $2 Billion per Year

MDA estimates that the GMD program will need approximately $12.8 billion over 6 fiscal years to continue developmental and fielding activities associated with Blocks 2004, 2006, and 2008. Table 24 shows the planned costs of the program by fiscal year through 2009, the last year for which MDA published its funding plans.

Table 24: GMD Planned Costs

Dollars in billions of then-year dollars

	Fiscal year						
Block	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Block 2004	$1.34	$0.86	$0	$0	$0	$0	**$2.20**
Block 2006	1.59	2.33	2.13	2.11	0	0	**8.16**
Block 2008	0	0	0	0	1.24	1.24	**2.47**
Total	**$2.93**	**$3.19**	**$2.13**	**$2.11**	**$1.24**	**$1.24**	**$12.84**

Source: Missile Defense Agency.

Note: Numbers may not add exactly because of rounding.

The budget given in table 24 does not capture the full cost of the Block 2004 GMD capability, which we estimate is approximately $18.49 billion.[9] As shown in table 25, our estimate includes the following:

- Developmental costs of approximately $12.37 billion, which cover funding from 1996 through 2003. Between 1996 and 2001, DOD expended $6.81 billion to develop the National Missile Defense program. The knowledge, software, and hardware gained from this program directly contribute to the development of the Block 2004 GMD element. In addition, $5.56 billion was expended in fiscal years 2002 and 2003 for the Block 2004 development of the GMD element.

- Block 2004 activities, scheduled for fiscal years 2004 and 2005, which are budgeted at $2.20 billion.

- Block 2006 funds amounting to $3.92 billion that are supporting activities planned for fiscal years 2004 and 2005. When the GMD program allocated its expected budget to planned blocks, it allocated funds earmarked to support Block 2004 activities to the Block 2006 budget. For example, the cost of flight tests conducted during Block 2004 was accounted for in the Block 2006 budget.

Table 25: Cost of Block 2004 GMD Defensive Capability

Dollars in billions of then-year dollars

	Fiscal year					
Cost category	**1996-2001**	**2002**	**2003**	**2004**	**2005**	**Total**
Sunk costs	$6.81	$0	$0	$0	$0	**$6.81**
GMD Block 2004 Test Bed[a]	0	3.07	2.49	0	0	**5.56**
GMD Block 2004 Test Bed/Initial Defensive Capability	0	0	0	1.34	0.86	**2.20**
GMD Block 2004/2006 development	0	0	0	1.59	2.33	**3.92**
Total	**$6.81**	**$3.07**	**$2.49**	**$2.93**	**$3.19**	**$18.49**

Source: Missile Defense Agency.

[a]This cost represents funding for both Program Elements 3011 and 3012, “Block 2004 Test Bed” and “GMD Development and Test Bed Upgrades,” respectively. Beginning in fiscal year 2004, these Program Elements were changed to “GMD Test Bed Block 2004” and “GMD Test Bed Block 2006.”

[9] This figure does not include additional costs needed to support the operation and sustainment of GMD.

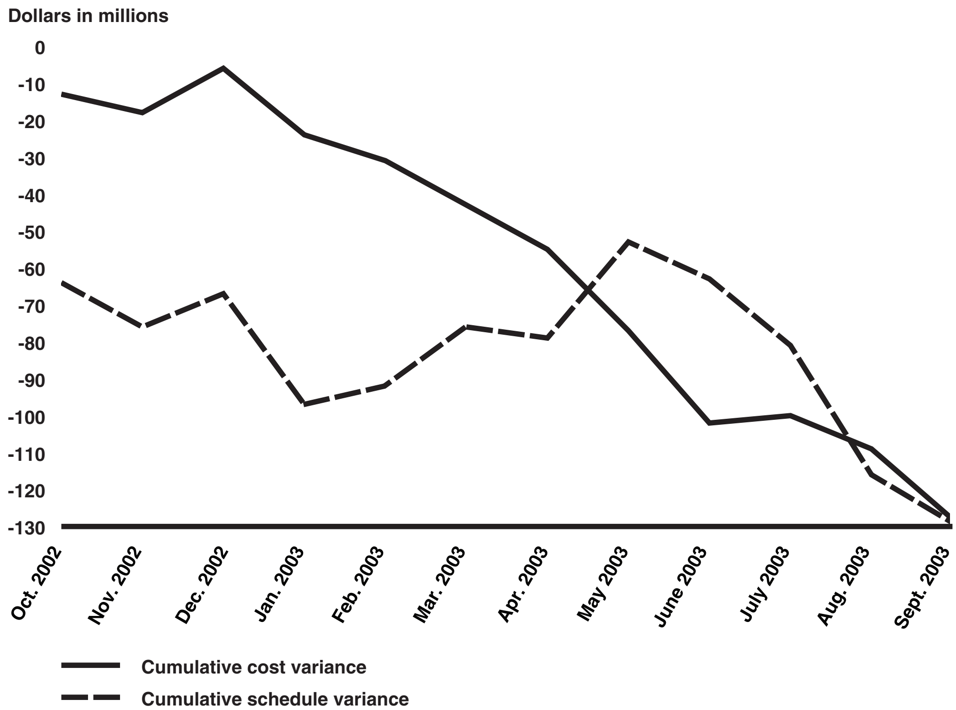
Prime Contractor Fiscal Year 2003 Cost and Schedule Performance: Budgeted Costs Exceeded by $138 Million

GMD's prime contract consumes the bulk of the program's budget. For example, about 80 percent of the fiscal year 2004-2009 budget is allocated to the prime contractor team and 20 percent to the government. The January 2001 GMD contract, which ends in fiscal year 2007, covers activities performed in Block 2004 and Block 2006. It was awarded prior to major changes in the missile defense program and, accordingly, the block approach and the procurement of interceptors for a defensive capability were not part of the original contract.

We used Cost Performance Reports to assess the prime contractor's cost and schedule performance during fiscal year 2003. The government routinely uses such reports to independently evaluate these aspects of the prime contractor's performance. Generally, the reports detail deviations in cost and schedule relative to expectations established under contract. Contractors refer to deviations as "variances." Positive variances—activities costing less or completed ahead of schedule—are generally considered as good news and negative variances—activities costing more or falling behind schedule—as bad news.

According to our analysis, the contractor's cost performance in fiscal year 2003 has steadily declined but schedule performance has been mixed. As shown below in figure 8, the GMD contractor exceeded its budgeted costs by approximately $138 million, which equates to 7.1 percent of the contract value over the fiscal year. The contractor also was unable to complete $51 million worth of scheduled work; most of the decline occurred during the second half of the fiscal year.

Figure 8: Fiscal Year 2003 Cost and Schedule Performance



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

Developmental issues with the interceptor have been the leading contributor to fiscal year 2003 cost overruns and schedule slips. Our analysis shows that the development of the GMD interceptor cost $127.2 million more in fiscal year 2003 than budgeted, and that the kill vehicle accounted for approximately 25 percent of this overrun. Moreover, booster development resulted in a $38 million cost overrun; the Lockheed BV+ booster was responsible for 52 percent of all of the interceptor's unfinished work.

Based on the contractor's cost and schedule performance in fiscal year 2003, we estimate that the current GMD contract—which ends in September 2007—will overrun its budget by between $237 million to $467 million, of which approximately 84 percent arising from the interceptor component. The contractor, in contrast, estimates no cost overrun at completion of the GMD contract. The contractor bases this assumption on the planned availability of $63 million in management reserve funds to offset cumulative cost overruns of approximately $128 million.[10] The intended purpose of management reserve funds, however, is not to offset cost overruns; rather, management reserves are a part of the total project budget that should be used to fund undefined, but anticipated, work. Although programs may use management reserves to offset cost variances, most programs wait until the work is almost completed prior to allocating these funds. The GMD contractor, in contrast, has completed only about 50 percent of the work directed by the program office. Program officials stated that the contractor is investigating sources of potential savings to offset interceptor cost overruns.

The cumulative schedule variance as of September 2003 was $128 million behind schedule. Therefore, to finish within budget and schedule, the contractor will have to improve its efficiency. According to our analysis, the GMD contractor has, effectively, been delivering $0.95 worth of scheduled work for every budgeted dollar that was spent to accomplish that scheduled work during fiscal year 2003. In order to complete all scheduled work at the budgeted cost, the GMD contractor will have to complete $1.01 worth of scheduled work for every dollar that will be spent to accomplish that scheduled work.

Program Risks

On the basis of our assessment of fiscal year 2003 activities, we found that the GMD program faces key risks in fielding the planned initial capability by September 2004 and the Block 2004 defensive capability by December 2005. These risks include readiness of interceptor production for the September 2004 IDO, limited testing before the system becomes operational, and a technical risk associated with the kill vehicle.

[10] The $128 million overrun pertains to the cumulative cost overrun incurred from the contract's inception through the end of fiscal year 2003 (September 2003). The $138 million overrun reported in this section is the overrun incurred during fiscal year 2003 only.

Contractor's Readiness to Produce Interceptors

The principal components of the GMD interceptor—the booster and kill vehicle—are at risk for falling short of production goals. The GMD program office had intended to field both BV+ and OSC boosters as part of the September 2004 IDO. However, developmental setbacks and supplier issues associated with the Lockheed BV+ booster have forced MDA to rely solely on the OSC booster for IDO. OSC's readiness to produce the additional boosters in the time remaining for IDO has not been established. Kill vehicle production is uncertain, as well. The contractor has yet to demonstrate that it can increase the production rate of kill vehicles by 50 percent—from 8 to 12 kill vehicles per year.

GMD program officials characterized the schedule to meet the September 2004 deadline for initial operations as extremely aggressive, with no margin for delay. Should interceptor production fall behind, the program will either have to field fewer interceptors than planned or delay planned fielding dates.

Limited Testing Before IDO

The GMD test program has been in a state of flux. The test program under the National Missile Defense program scheduled 16 integrated flight tests (intercept attempts) to be carried out between fiscal years 1999 and 2004. The current GMD test program, however, consists of 10 intercept attempts over the same time period. The change stems from the cancellation of IFT-11, IFT-12, and IFT-16; the conversion of IFT-13 to boost validation tests (IFT-13A and IFT-13B); and the delay of IFT-17 and IFT-18 into fiscal year 2005.

MDA had scheduled two flight tests—IFT-14 and IFT-15—to be conducted before September 2004, but only IFT-14 is now planned before then. IFT-14 is particularly relevant because it is planned to utilize production-representative hardware and operational software for the first time in an intercept attempt. The following firsts are expected to occur in IFT-14, which is scheduled for 4Q FY 2004:

- The new OSC booster will be used—all previous tests employed surrogate boosters.
- A production-representative kill vehicle, which incorporates new hardware and discrimination software, will be tested.

- A new, operational build of the fire control (battle management) software will be used to control the GMD engagement.

While MDA will gain some confidence from the successful execution of IFT-14, this test provides only a single opportunity to demonstrate the components to be fielded as part of IDO and to resolve any problems uncovered during flight testing.

The previous test program for the NMD system, the predecessor to GMD, also called for operational testing by the military services, a statutory requirement to characterize operational effectiveness and suitability of a deployed system for use by the warfighter. MDA does not plan to operationally test the GMD element before it is available for IDO or Block 2004. The fielding is not connected with a full-rate production decision that would clearly trigger statutory operational testing requirements. The Combined Test Force, a group of users and developers, plans tests to incorporate both developmental and operational test requirements in the test program. In addition, MDA is introducing some elements of operational testing into developmental tests, such as soldier participation during some developmental tests. However, GMD's current test program does not include flight tests conducted under the unrehearsed and unscripted conditions characteristic of operational testing.

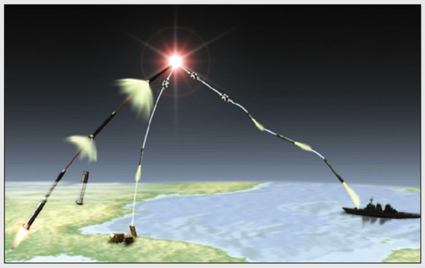
Technical Risk of the Kill Vehicle

A technical problem in the kill vehicle observed in earlier flight tests could affect the operational effectiveness of the GMD element. Although the program office indicated that the issue has been resolved, theories of and solutions for the anomaly have not been verified in flight. The next attempt for verification will occur in integrated flight test 13C (IFT-13C), which is scheduled for 3Q FY 2004.[11]

[11] Additional details are provided in a classified annex to this report.

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 an initial land-based capability in the 2010-11 time frame, followed by a sea-based capability during 2012-13.

The Department of Defense (DOD) budgeted about $7.9 billion for KEI development during fiscal years 2004 through 2009. About $91.5 million was invested in KEI's immediate predecessor program in fiscal year 2003.

Fiscal Year 2003 Progress Assessment

KEI program activities in fiscal year 2003 primarily revolved around the selection of a prime contractor for KEI's development and testing. The program also continued with experimental work geared toward collecting the data of boosting missiles.

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. In addition to contractual and source-selection activities completed in 2003, the KEI program office continued with activities designed to reduce technical risks in developing the KEI interceptor. In particular, the program office continued with technical work pertaining to an experiment for collecting data on boosting missiles, known as the Near Field Infrared Experiment. This work is expected to culminate with a satellite launch during the fall of 2005.

Performance: Because this element is still in its infancy, data are not yet available to make a performance assessment.

Cost: According to the KEI program manager, the prime contract incorporates various innovative acquisition initiatives, which are expected to encourage the contractor to develop a quality product on time and within the initially proposed price. Because the prime contract was awarded in December 2003 (fiscal year 2004), no fiscal year 2003 data existed for an assessment of the contractor's cost and schedule performance.

Key risks: The program office acknowledges that it faces general challenges in developing the first capability that uses a missile to destroy another missile in the boost phase of flight. From discussions with program officials, we also found that KEI software costs could be underestimated, putting the program at risk for cost growth and schedule delays.

Kinetic Energy Interceptors

Background: 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 when a missile's rocket motors are thrusting. KEI also provides the opportunity to engage enemy missiles in the early-ascent phase, the period after booster burnout before the missile can release warheads and countermeasures. Initially, the program is focused on developing a mobile, land-based system—to be available in the Block 2010 time frame—that counters long-range ballistic missile threats. Subsequent efforts will include sea- and space-based efforts that provide protection against all classes of ballistic missile threats.

The land-based system will be a deployable unit consisting of a command and control/battle management unit, mobile launchers, and interceptors. Program officials noted that because the KEI element has no sensor component such as radars, it would rely on Ballistic Missile Defense System (BMDS) sensors (space-based infrared sensors and forward-deployed radars) for detection and tracking functions. Like other existing hit-to-kill interceptors, the KEI interceptor is comprised of a booster and kill vehicle. The kill vehicle is expected to employ an infrared seeker derived from the Aegis BMD program and divert thrusters, which provide terminal guidance and control, derived from the Ground-based Midcourse Defense (GMD) program.

Background: History

In the summer of 2002, the Defense Science Board recommended that the Missile Defense Agency (MDA) initiate a program to develop a boost/ascent-phase interceptor capable of countering intermediate- and long-range ballistic missile threats. Work in this area was initiated in fiscal year 2003 under the Kinetic Energy Boost program as part of MDA's Boost Defense Segment. Beginning with fiscal year 2004, this program has been budgeted under a new MDA area known as BMDS Interceptors, which includes the KEI element.

Background: Developmental Phases

KEI's development is proceeding in a series of planned two-year blocks known as Blocks 2010, 2012, and 2014. Concurrently, the KEI program is conducting risk mitigation projects to determine whether a space-based platform, from which interceptors could be launched, is feasible and affordable. Other blocks may follow, but on the basis of recent budget documentation, MDA has not yet defined their content.

Block 2010: The KEI program entered the Development and Test Phase in December 2003, after MDA selected Northrop Grumman as the prime contractor. The contractor has begun development activities leading to a Block 2010 capability, the first increment of land-based interceptors capable of destroying ballistic missiles during the boost or early-ascent phases of flight. MDA envisions that these first-generation interceptors will be built and launched from trucks that can be driven up close to the border of the threatening nation.

Block 2012: This block increment expands KEI's Block 2010 capabilities to include the capability to launch interceptors from sea-based platforms such as Aegis cruisers or submarines. A study is under way to select the platforms. The Block 2012 sea-based capability will use the interceptor developed for Block 2010.

Block 2014: During this block, the interceptor is expected to evolve into a new, multiuse interceptor capable of performing boost, early-ascent, and midcourse-phase intercepts from platforms on land or sea.

Progress Assessment: Schedule

The KEI program office's activities in fiscal year 2003 primarily revolved around the selection of a prime contractor for KEI development and testing. Activities involving the Near Field Infrared Experiment (NFIRE), which focus on reducing technical risk through experiments that collect data on the plume of boosting missiles, were also carried out in fiscal year 2003.

Prime Contract Awarded to Northrop Grumman

In March 2003, two KEI concept design contracts worth $10 million each were awarded to competing teams headed by Northrop Grumman and Lockheed Martin. These contracts preceded MDA's selection of Northrop Grumman in December 2003 as the element's prime contractor.

The Northrop Grumman $4.6 billion cost plus award fee contract employs a unique acquisition strategy that places mission assurance—the successful operation of the element to perform its mission—as a program priority. To implement this strategy, MDA based its source selection decision on the extent to which the contractor's past performance produced successful results on programs of similar complexity, as well as on the performance of the proposed design. MDA also built incentives into the contract that require the prime contractor to achieve 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.

Experimental Activities Under Way

NFIRE, scheduled for a fall 2005 launch, is being funded under the KEI program as a risk-reduction activity to collect phenomenology data on boosting missiles. The experiment consists of launching an experimental satellite that is designed to record infrared imagery of a ballistic missile's plume and the body of the missile itself. Data from NFIRE will help MDA develop algorithms and assess its kill vehicle design for boost-phase missile defenses.

In addition to NFIRE, the KEI program is working on a variety of risk reduction activities. For example, work is being done in support of space-based KEI development, including miniaturization, weight reduction, and producibility of satellite and interceptor subcomponents.

Program Assessment: Performance

At this early stage of element development, data are not available to make a performance assessment.

Program Assessment: Cost

MDA expects to invest about $7.9 billion from fiscal year 2004 through 2009 to develop the KEI element. This is in addition to the approximately $91.5 million invested in the program's immediate predecessor, the Kinetic Energy Boost program.

According to the KEI Program Manager, the program is incorporating various innovative acquisition initiatives into the KEI development and testing contract. He told us that these initiatives are expected to encourage the contractor to develop a quality product on time and within the initially proposed price.

Because the prime contract was awarded in December 2003 (fiscal year 2004), no fiscal year 2003 data existed for an assessment of the contractor's cost and schedule performance.

Total Program Cost: KEI Program Costing Approximately $1.3 Billion per Year

The KEI program's planned costs for the next 6 fiscal years are expected to be around $7.9 billion. This covers land- and sea-based KEI development, ground-based risk mitigation projects to determine the feasibility of a space-based platform, and international cooperation projects. Of the $7.9 billion, approximately $4.8 billion is allocated to the land-based capability. Table 26 shows the expected costs of the program by fiscal year through 2009, the last year for which MDA published its funding plans.

Table 26: KEI Planned Cost

Dollars in millions of then-year dollars

	Fiscal year						
Block	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Block 2010	$112	$451	$971	$1,275	$1,215	$670	**$4,583**
Block 2012	0	47	131	422	947	1,739	**3,286**
Total	**$112**	**$498**	**$1,102**	**$1,697**	**$2,162**	**$2,409**	**$7,869**

Source: Missile Defense Agency.

The immediate predecessor of the KEI element, Kinetic Energy Boost, was funded in fiscal year 2003 under the Boost Defense Segment[1] and had a budget of $91.5 million.

Program Acquisition Initiatives

The prime contract awarded in December 2003 was based on a number of innovative acquisition strategies. First, the program gave competing contractors flexibility to design a system that met only one broad requirement—that the KEI element be capable of reliably intercepting missiles in their boost/ascent phase. MDA did not set cost or schedule requirements or specify how the contractors should design the system. Second, upon award of the development contract, the program locked the winning contractor into firm, fixed-price commitments for the production of a limited number of interceptor, launcher, and battle-management components. Third, the program office included an option in the contract for a commercial type "bumper-to-bumper warranty." Finally, the contract stipulates that the contractor earns an award fee only if flight tests are successful. Additionally, the fee is reduced if the tests are not conducted on

[1] Program Element 0603883C, "BMD Boost Defense Segment."

schedule. The Program Manager told us that the program's goal was to provide the contractor with incentives to develop a quality product on schedule and at the originally proposed price.

Additionally, consistent with the MDA acquisition approach, the KEI program plans to conduct annual continuation reviews to determine if the KEI program and its prime contract should continue. These reviews focus on contractor performance and external conditions, such as potential threats or MDA's funding priorities.

One initiative of the program's acquisition strategy is the inclusion in Northrop Grumman's development contract of a firm, fixed unit production price for all of the element's components—launcher, interceptor, and battle management. This initiative is unique because the production price was agreed upon before the contractor developed the component's design and because the price was a factor in MDA's choice of Northrop Grumman as the KEI prime contractor. Program officials believe that the government benefited from this strategy, because competition encouraged Northrop Grumman and Lockheed Martin, which were competing for the contract, to offer MDA their best production price.

According to program officials, Northrop Grumman could ask for a price increase, should it find, when production begins, that it cannot produce the components at the agreed-upon price. However, the price increase would come with a cost to the contractor. Northrop Grumman would have to provide data to support the new price, which would be time-consuming, and therefore, costly.

Although this initiative appears to be beneficial to MDA, the agency could find when it reaches the production phase that it has not budgeted sufficient funds to support the production program. According to a study conducted by the Institute for Defense Analyses, requiring a binding price commitment during the development phase of an acquisition program provides the contractor with a significant incentive to underestimate production costs. The study goes on to explain that because of a similar initiative in the 1960s, a statistically significant number of contractors experienced production costs much greater than the firm fixed price agreed upon. Furthermore, the former head of the Defense Department's independent cost estimating office stated that the only time it makes sense to request a fixed production unit price at this point in a weapon system's development is when the weapon is a low-technology project whose requirements and funding are stable. These criteria do not apply to KEI.

Rather, the KEI contractor is being asked to develop a technologically advanced system associated with the challenging mission of boost phase intercepts.

Program Risks

The program office acknowledges that it faces challenges in developing the first operational boost phase intercept capability that employs hit-to-kill concepts. In addition, from discussions with program officials, we found that KEI's software costs could be underestimated, putting the program at risk for cost growth and schedule delays.

Technical Challenges

The scientific and missile defense communities recognize that the boost phase intercept mission is technically and operationally challenging, particularly because of the short timeline involved with engaging a boosting missile. For example, in its July 2003 report on boost phase intercept systems,[2] the American Physical Society concluded that boost-phase defense of the entire United States against solid-propellant ICBMs is unlikely to be practical when all factors are considered, no matter where or how interceptors are based. According to the report, even with optimistic assumptions, a terrestrial-based system would require very large interceptors with extremely high speeds and accelerations to defeat a solid-propellant ICBM launched from even a small country such as North Korea.

Furthermore, a scientific study on boost-phase defense commissioned by MDA[3] focused on selected issues of high risk, including methods for early launch detection of missile launches, interceptor divert requirements, and discrimination of the missile's body from its luminous exhaust plume.[4] The study concluded that there are no fundamental reasons why an interceptor cannot hit a boosting target with sufficient accuracy to kill the warhead. However, the study identified several challenges, including understanding the plume phenomenology well enough to have confidence in the

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

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

[4] Plume-to-hardbody handover.

appropriate sensor combination chosen for the interceptor. Both studies highlighted the short timeline that the boost-phase system will have to detect and hit an enemy missile as a key area of concern.

Software Costs

The KEI Program Office is uncertain of whether the negotiated cost of the prime contract includes sufficient funds to complete software development for the various KEI components, including the battle-management, interceptor, and launcher components. Northrop Grumman based its estimates of software development on comparisons with similar systems—such as GMD and Aegis BMD—and on a projection that existing software could be reused. MDA officials from the program office told us that they were somewhat concerned that Northrop Grumman underestimated the amount of software it could reuse from the GMD program for the KEI program.

Software growth in weapon systems programs has traditionally been problematic. Historically, a contractor must develop twice as many lines of software code for the weapon system as it initially estimated. This growth has occurred when contractors underestimate the effort, make invalid assumptions regarding the extent to which existing software code can be reused, and make unrealistic assumptions about how quickly software can be produced. If software growth in the KEI program increases at the historical rate, the amount of software needed by the element will likely exceed the contractor's initial estimate of 1 million lines of code, causing cost increases and schedule delays.

According to program officials, MDA discussions with Northrop Grumman resulted in a reduction of its estimate of the amount of existing software code that could be reused in the KEI element. However, the officials told us that the program is still concerned that the contractor's estimate is optimistic.

Software estimates typically include an analysis of uncertainty, which indicate the reliability of the contractor's estimates for the software development effort. KEI program officials noted that the contractor performed an uncertainty analysis for the interceptor component but not for the battle management component that includes the bulk of the KEI software code.

Conclusion

If the KEI contractor cannot develop the software within the negotiated cost of the KEI contract, MDA could find itself in the position of having to locate funds to cover cost overruns. MDA would benefit from quickly recognizing this funding shortfall because, with time, it might be able to locate funding without causing significant perturbations in the KEI or other element's programs. Also, if additional funding were needed, making the funds available to the contractor early in the development effort would allow the contractor to increase personnel so that the effort would not fall behind schedule. Completing uncertainty analyses for all components of the KEI element is the best means of determining if such a funding shortfall is likely.

Recommendation for Executive Action

We recommend that MDA analyze the degree of risk associated with the KEI software components by performing an uncertainty analysis that quantifies the reliability of the proposed estimates.

Appendix VII Summary

Space Tracking and Surveillance System

Source: Missile Defense Agency

Program Description

The Space Tracking and Surveillance System (STSS) will eventually comprise a constellation of low-orbiting satellites used to detect and track enemy missiles throughout all phases of flight. The Missile Defense Agency (MDA) manages STSS, which replaces the Air Force's Space-Based Infrared System-Low (SBIRS-Low) program. The STSS program office is preparing to launch in 2007 two demonstration satellites that were built under the SBIRS-Low program. After launch, MDA plans to assess how well these demonstration satellites perform missile defense surveillance functions. On the basis of this assessment, the agency will determine capabilities and goals for next-generation STSS satellites.

The Department of Defense (DOD) budgeted about $4.15 billion for STSS's development during fiscal years 2004 through 2009. Earlier, MDA expended about $540 million in fiscal years 2002 and 2003. In addition, from program initiation through 1999, the SBIRS-Low program invested $686 million to develop the demonstration satellites that are now part of the STSS program.

Fiscal Year 2003 Progress Assessment

The STSS program office completed most activities on time and slightly over budget during fiscal year 2003. However, cost and schedule performance could potentially slip because of unforeseen problems arising during the process of preparing the satellites for launch.

Schedule: Program activities completed in fiscal year 2003 were focused on the ground testing of existing hardware rather than on the design and development of future STSS satellites. Equipment built for the SBIRS-Low program was retrieved from storage and tested to determine whether individual components were still in good working order. Testing of the first demonstration satellite's hardware—the spacecraft itself and infrared sensors—was completed on time, and testing of the second satellite is to be completed by August 2004, slightly behind schedule. Software development activities also have been completed. However, STSS program officials are closely monitoring the development of software for the satellites' sensors because software requirements have not been finalized.

Performance: STSS's indicators show that the program is on track for meeting performance requirements.

Cost: Our analysis of prime contractor cost performance reports shows that the contractor completed work in fiscal year 2003 at slightly more cost than budgeted. Specifically, the contractor overran budgeted costs by less than $1 million and could not complete about $6.4 million worth of work. Because of changes made to the contract during this time, more data are needed to determine whether the entire contract will exceed its projected cost and schedule. The contractor reported that sensor-related issues are among the problems that contributed to the cost overrun and schedule delays. These problems, the contractor said, could jeopardize the overall delivery of the satellites.

Risks: On the basis of our assessment of fiscal year 2003 activities, we did not identify any evidence that the STSS program will be unable to launch the two demonstration satellites in 2007. However, MDA identified a number of risk areas that have the potential to increase the program's cost and delay the 2007 launch of these satellites. Unforeseen problems could arise during the testing, assembling, and integration of hardware components of the satellites, which had been in storage for 4 years. Officials cannot predict which components will be found in nonworking order or the costs associated with fixing them. Also, software development and software and hardware integration are areas that historically have been responsible for affecting a program's schedule.

Space Tracking and Surveillance System

Background: Element Description

The Space Tracking and Surveillance System (STSS) is being developed as an integrated element of the Ballistic Missile Defense System (BMDS). The Missile Defense Agency (MDA) envisions that the STSS element will be comprised of a constellation of low-orbiting satellites to detect and track enemy missiles throughout all phases of flight—from launch through midcourse and into reentry. Any real operational capability, however, would not be realized until the next decade.

The STSS program is currently working on the first increment of the STSS element, known as Block 2006. Schedule and technical performance objectives for the Block 2006 element are detailed in the MDA Director's Guidance, which directs the STSS program office to prepare and launch two demonstration satellites that were partially built under the Air Force's Space-Based Infrared System-Low (SBIRS-Low) program. The two satellites each contain two infrared sensors, one that would acquire targets by watching for bright missile plumes during the boost phase (an acquisition sensor), and one that would track the missile through midcourse and reentry (a tracking sensor). MDA plans to launch these satellites in 2007, in tandem, in an effort to assess how well they perform the missile defense surveillance and detection 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.

Background: History

Over the past two decades, the Department of Defense (DOD) initiated a number of programs and spent several billion dollars trying to develop a system for tracking missiles from space. Owing partially to the technical challenges associated with building such a system, DOD did not successfully launch any satellites or demonstrate any space-based midcourse tracking capabilities. Program managers did not fully understand the challenges in developing these systems and, accordingly, schedules were overly optimistic and program funding was set too low. For example, sensors aboard the satellites must be able to track deployed warheads in the midcourse phase of flight in contrast to the bright plume of boosting missiles. To perform this mission, onboard sensors must be cooled to low temperatures for long periods of time and be able to withstand the harsh environmental conditions of space.

The last program under development for detecting and tracking missiles from low-earth orbits in space[1] was SBIRS-Low, which DOD established in 1996 to support national and theater missile defense. Its mission was to track missile complexes over their entire flights and to discriminate warheads from decoys. The SBIRS-Low program experienced cost, schedule, and performance shortfalls. As a result, DOD cancelled the accompanying technology program in 1999—the two-satellite Flight Demonstration System—and put the partially constructed equipment into storage.

In October 2000, Congress directed DOD to transfer the SBIRS-Low program to the Ballistic Missile Defense Organization (now MDA). When MDA inherited SBIRS-Low, the agency decided to make use of the equipment that was partially built under the SBIRS-Low technology program by completing the assembly of the equipment and launching the two satellites in 2007 to coincide with broader missile defense tests. At the end of 2002, the SBIRS-Low program became STSS.

Background: Developmental Phases

STSS's development is proceeding in a series of planned 2-year blocks. Near-term blocks are known as Blocks 2006, 2008, and 2010. Other blocks may follow, but on the basis of recent budget documentation, MDA has not yet defined their content.

Block 2006. Block 2006 involves the assembly, integration, testing, and launch of two demonstration satellites in 2007, as described above.

Block 2008. Block 2008 is primarily an upgrade of Block 2006 ground stations, which are used to collect and analyze data from Block 2006 satellites. The software upgrades will benefit both the demonstration satellites as well as future satellites.

Block 2010. The Block 2010 program is essentially a new phase of STSS development. Building upon lessons learned from the previous development efforts and blocks, Block 2010 involves the design and development of new-generation satellites, which are expected to include more robust technologies. MDA plans to launch the first of these in 2011.

[1] The satellites were to operate at about 1,350 kilometers above the earth. By comparison, satellites in geo-synchronous orbit operate at about 36,000 kilometers.

Progress Assessment: Schedule

The STSS program office has completed most activities planned for fiscal year 2003. According to the program office, the contractor has been performing to an accelerated delivery schedule, and activities associated with testing and completing the two satellites have proceeded with fewer problems than anticipated. About 30 percent of Block 2006 activities have been completed, but the fiscal year 2003 activities were generally simple. For example, they involved taking the equipment out of storage and performing individual component testing to determine whether any degradation in the equipment had occurred over time. The program still has many more tasks before the satellites will be ready for launch, such as completing software development and integration activities.

Block 2006 activities achieved during fiscal year 2003 can be divided into three categories. Specifically, the STSS program office worked to

- test hardware components of existing satellites;
- develop satellite software, as needed, not developed under the previous program; and
- prepare for a design review to be held in early fiscal year 2004 to ensure the design's adequacy to support its BMDS mission.

Testing of Existing Hardware: Most Activities Proceeding as Planned

At the beginning of the STSS program in 2002, MDA retrieved from storage the satellite components that were partially constructed under the SBIRS-Low program. STSS contractors retrieved these legacy components and are in the process of testing the satellite spacecraft (the space platform) and its payload (infrared sensors and supporting subsystems) to ensure that this hardware is still in working order. Testing of the first satellite's components is complete: sensor hardware testing began in November 2002 and was completed in October 2003; the spacecraft's hardware testing began in May 2003 and was completed in September 2003.

Part of the testing of the component hardware of the second satellite is proceeding as planned. Although there was a delay in the start of the spacecraft testing, the second satellite's component testing remained on schedule. For example, STSS contractors have visually inspected the satellite's spacecraft hardware. Spacecraft hardware testing was originally scheduled to begin in September 2003 and be completed in November 2003. However, it did not begin until November 2003 and is now scheduled to be completed in May 2004. Payload hardware testing began in December 2003 but will not be finished until August 2004. Table 27 summarizes the activities and completion dates associated with hardware testing.

Table 27: Block 2006 STSS Activities—Testing Hardware Components

Test activity	Actual/Planned completion date	Comments
Payload Flight 1 hardware testing	Oct. 2003	Completed on schedule
Spacecraft Flight 1 hardware testing	Sept. 2003	Completed on schedule
Payload Flight 2 hardware testing	Aug. 2004	Ongoing
Spacecraft Flight 2 hardware testing	May 2004	Ongoing

Source: Missile Defense Agency.

Software Development Slightly Behind Schedule and More Challenging Efforts Remain

Table 28 summarizes the principal software development activities completed in fiscal year 2003 pertaining to software development for the spacecraft and for the ground segments.

Table 28: Block 2006 STSS Activities—Software Development

Activity	Date completed	Comments
Ground Segment Requirements Definition	Dec. 2002	Completed ahead of schedule
Spacecraft Flight Software (Build 3)	Jan. 2003	Completed on schedule
Spacecraft Flight Software Integration and Test (Build 3)	Mar. 2003	Completed on schedule
Ground Design (Build 1)	Mar. 2003	Completed 2 weeks late
Spacecraft Flight Software (Build 4)	Dec. 2003	Completed 4 months late

Source: Missile Defense Agency.

Most activities completed to date have finished at or slightly behind schedule. However, the STSS program office is closely tracking the development of payload software, because there is significant cost, schedule, and performance risk associated with the effort. In particular, the program office has not fully established software requirements. Studies have shown that when operational needs are not well defined, the associated software effort tends to grow, resulting in large cost overruns, schedule slips, and reduced functionality. These risks are compounded by the fact that software from the SBIRS-Low program was not completed or sufficiently documented. STSS program officials are concerned that the extent of software reuse might have been optimistic and, consequently, software development costs could be more than double the originally proposed cost.

Design Review Successfully Conducted

The STSS program office conducted a single design review in fiscal year 2003—the System Preliminary Design Review. According to the program office, although it was delayed by 1 month, the outcome was successful. During the latter part of fiscal year 2003, the program office began preparing for the System Critical Design Review, which was successfully completed early in fiscal year 2004.

Progress Assessment: Performance

The Block 2006 STSS satellites are built from legacy hardware and will be used as technology demonstrators (rather than for operational missions). The program considers that demonstration of STSS functionality as more critical than the demonstration of STSS effectiveness in performing the functions. The rationale is to keep costs within budget, especially for satellites that have an in-orbit life of 18 to 24 months. Nonetheless, data provided to us by MDA indicate that all STSS performance indicators, with the exception of the one pertaining to the visible sensor, are on track for meeting their respective requirements.

Progress Assessment: Cost

MDA expects to invest about $4.15 billion from fiscal year 2004 through 2009 in the element's development. This is in addition to the approximately $1.2 billion invested in the SBIRS-Low program from the program's initiation in 1996 through fiscal year 1999 and in the STSS element from 2002 through 2003.

In fiscal year 2003, the contractor reported that its work cost slightly more than budgeted and that it was somewhat behind schedule. We were unable to make an independent assessment of the contractor's cost and schedule performance because of contract changes. The contractor was working toward a single-launch (tandem launch) strategy while measuring performance against a two-launch strategy. Also, the contractor was reporting against an accelerated schedule that was not required by the contract.

Total Program Cost: STSS Program Costing Approximately $700 Million per Year

STSS's costs for the next 6 fiscal years are expected to be approximately $4.15 billion. These funds will finance activities for Block 2006, Block 2008, and the development of new-generation satellites planned for Block 2010. Table 29 shows the expected costs of the program by fiscal year through 2009, the most recent year for which MDA published its funding plans.

Table 29: Planned Annual Cost

Dollars in millions of then-year dollars

	Fiscal year						
Block	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Block 2006	$267	$274	$260	$183	$47	$52	**$1,082**
Block 2008	0	0	0	25	30	20	**74**
Block 2010	22	48	254	637	920	1,113	**2,994**
Total	**$289**	**$322**	**$513**	**$845**	**$997**	**$1,184**	**$4,150**

Source: Missile Defense Agency.

Note: Numbers may not add exactly because of rounding.

Prior to fiscal year 2004, MDA spent approximately $250 million and $294 million in fiscal years 2002 and 2003, respectively, for this program. Furthermore, the SBIRS-Low program invested $686 million to develop the demonstration satellites that are now part of the STSS program.

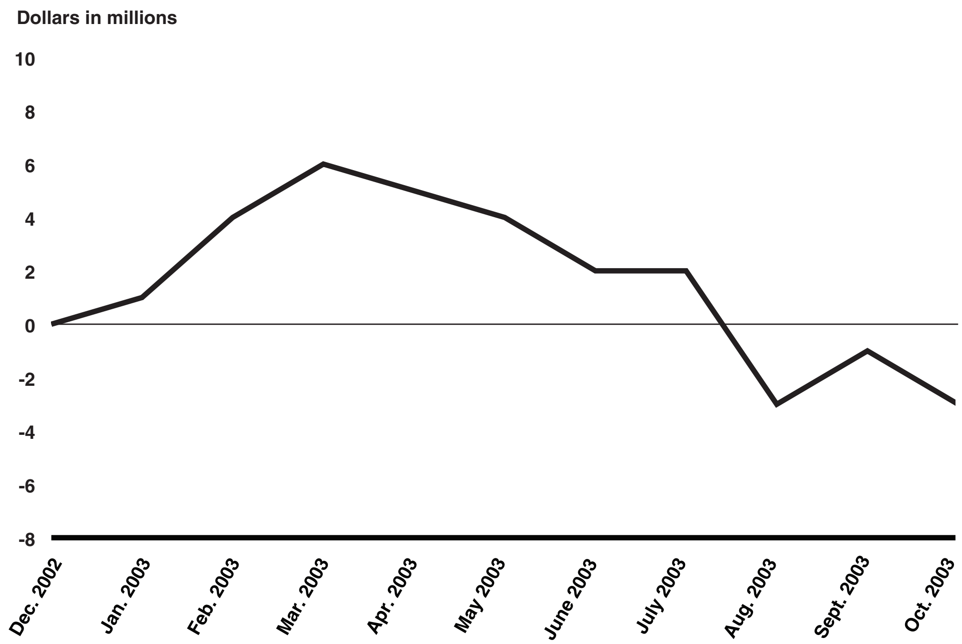
Prime Contractor Cost and Schedule Performance: Contractor Reports Declining Cost and Schedule Performance

In fiscal year 2003, the contractor reported that its work cost slightly more than budgeted and that it was somewhat behind schedule. Although the contractor's cost performance was positive through the first half of fiscal year 2003, it began to decline in March 2003 and continues to do so. Schedule performance began to decline in December 2002 and continued throughout fiscal year 2003.

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—activities costing less or completed ahead of schedule—are generally considered as good news and negative variances—activities costing more or falling behind schedule—as bad news.

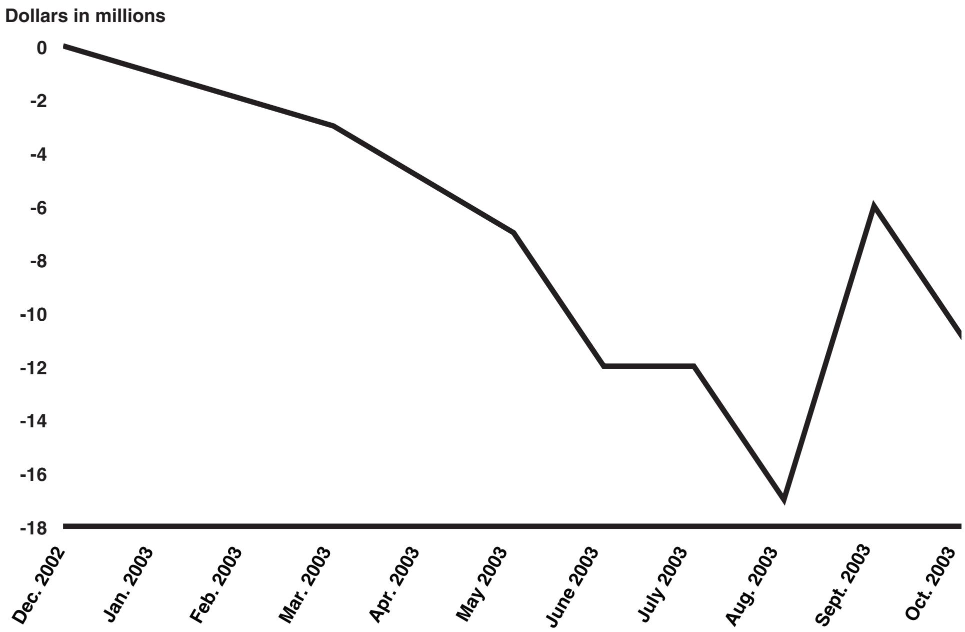
Figures 9 and 10 show the STSS contractor's cost and schedule performance during fiscal year 2003. According to Cost Performance Reports, work completed during fiscal year 2003 cost about $1 million more than estimated—as indicated by the September 2003 data point—and the contractor could not complete about $6.1 million worth of the work scheduled for the same time period.

Figure 9: Fiscal Year 2003 Cost Performance



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

Figure 10: Fiscal Year 2003 Schedule Performance



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

Because of contract changes, we could not fully rely upon the data reported in the contractor's Cost Performance Reports to make our own analysis of the STSS contractor's cost and schedule performance. In April 2003, the STSS program office altered its launch strategy in response to funding cuts. Rather than carrying out two separate launches, the program decided to launch the two satellites in tandem, which means one launch vehicle will place both satellites into orbit. The STSS program office notified the contractor in April 2003 of the change, but the contractor did not formally adjust its performance measurement baseline[2] to reflect the tandem launch until September 2003. According to the program office, the tandem launch resulted in minimal changes to the contract's overall cost and schedule. However, officials told us that it did result in changes in the content, budget, and schedule of individual work tasks. Therefore, throughout most of fiscal year 2003, the contractor was completing work

[2] A performance measurement baseline reflects all of the work tasks that must be performed to meet contract objectives and the schedule and budget for performing each task.

tasks for the tandem launch. However, the contractor's cost and schedule performance was being measured against work tasks reflected in the two-launch strategy. Because the baseline that the contractor used to measure its performance during most of fiscal year 2003 did not always reflect the actual work being done, Cost Performance Reports for April through September may not provide a clear picture of the contractor's cost and schedule performance. In September 2003, the contractor adjusted the contract's work tasks, along with their budgets and schedules, to reflect the change to a tandem launch.

Another factor complicating our analysis is that the contractor established a performance measurement baseline on the basis of an accelerated schedule for completing the work. The contractor did this in response to a unique cost-control incentive in the STSS Award Fee plan. The plan allows the contractor to earn up to 50 percent of a potential cost under-run if it can deliver the two satellites (1) up to 6 months early, (2) for less than the negotiated cost, and (3) meeting all orbit performance requirements. As a direct result of this incentive, the contractor elected to implement a performance measurement baseline that reflected a 6-month accelerated schedule. This means that the contractor might be performing work on a schedule that would allow it to complete all work by the end of the contract, but Cost Performance Reports could show that work was falling behind schedule.

All cost and schedule performance data for fiscal year 2003, as reported by the contractor, are illustrated in figures 9 and 10. We adjusted schedule data to reflect the accelerated schedule, but we could not adjust cost or schedule data to account for the change to a tandem launch. Because we could not make these adjustments, we also included Cost Performance Report data for October 2003 in the figures. The October report is the first report the contractor issued after adjusting its performance measurement baseline to account for the tandem launch. In our opinion, the October report is a better indicator of the contractor's performance. However, we note that further data are needed before an estimate can be made of whether the cost and schedule of the entire contract are likely to be more than projected.

In October 2003, the STSS contractor reported a cumulative cost overrun of approximately $3 million. It attributed this overrun to sensor issues, sensor payload test plan inefficiencies, more costly custom interface assembly, and tasks being more complex than planned. Also in October, the contractor reported it was approximately $11 million behind schedule. In our opinion, this might have an unfavorable impact on the program, because additional funding may be needed to make up the lost schedule. The contractor reported that schedule delays were attributed to sensor-testing problems with flight hardware, payload test procedures taking longer than expected, rigorous Failure Review Board reviews, and problems with the sensor- and payload-tracking algorithms. The contractor reported that these problems could jeopardize the overall delivery of the satellites.

Program Risks

On the basis of our assessment of fiscal year 2003 activities, we did not identify any evidence that the STSS program would be unable to launch the two demonstration satellites in 2007. However, MDA identified a number of areas that have the potential to increase the program's cost and delay the 2007 launch of these satellites. We recognize that unforeseen problems could be discovered through testing, assembling, and integrating the hardware and software components of the satellites. MDA cannot predict which components will be found in nonworking order or the costs associated with fixing them. A related issue is the availability of original suppliers. Because the equipment was in storage for several years, the original equipment manufacturers may not offer maintenance for some of the parts considered obsolete. If replacement parts are needed as a result of failures or redesigns, this could create schedule delays for the program. Finally, the STSS program has also identified a number of activities that have the potential to affect the program's schedule, including completing software development and related integration activities.

Source: Missile Defense Agency

Appendix VIII Summary

Theater High Altitude Area Defense

Program Description

The Theater 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 operational capability consisting of tens of missiles during the 2008-09 time frame.

The Department of Defense (DOD) budgeted about $4.3 billion for THAAD's development during fiscal years 2004 through 2009. Earlier, DOD expended about $6.5 billion between the program's inception in 1992 and 2003 for related developmental efforts.

Fiscal Year 2003 Progress Assessment

THAAD's prime contractor performed less efficiently in fiscal year 2003 than in previous years. However, the contractor is, overall, under budget and ahead of schedule. Our analysis indicates that missile development was the principal cause of the decline in the contractor's cost and schedule performance during fiscal year 2003.

Schedule: Because THAAD previously was under Army management, the current program office re-planned THAAD's primary research and development contract to accommodate the Missile Defense Agency's (MDA's) acquisition approach. The office also completed Block 2004 design reviews largely on schedule. In addition, the program conducted ground tests in preparation for initial flight testing, which is scheduled to begin at the end of 2004. However, explosions that occurred in 2003 at a propellant mixing facility could jeopardize deliveries of THAAD boosters and already have delayed the first flight test—a non-intercept test scheduled for the first quarter of fiscal year 2005—up to 3 months. Nevertheless, the program office expects to maintain the schedule for the first intercept attempt, currently scheduled for the fourth quarter of fiscal year 2005.

Performance: The program office told us that key indicators show that THAAD is on track to meet operational performance goals. However, data from flight testing are necessary to anchor end-to-end simulations of THAAD operations to confidently predict the element's effectiveness.

Cost: Our analysis of prime contractor cost performance reports shows that the contractor's positive cost and schedule variance were somewhat eroded during fiscal year 2003, which was driven by the missile component but offset by other THAAD components. With 49 percent of the THAAD contract completed, the prime contractor is, overall, under budget and ahead of schedule.

Risks: On the basis of our assessment of fiscal year 2003 activities, we did not find evidence of key risks that could affect MDA's ability to develop, demonstrate, and field the THAAD element during the 2008-2009 time frame within scheduled and cost estimates. However, it is too early to state with confidence whether the element will or will not be ready for integration into the Ballistic Missile Defense System during this time.

Theater High Altitude Area Defense

Background: Element Description

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

A THAAD unit consists of a command and control/battle management component for controlling and executing a mission, truck-mounted launchers, interceptors,[2] an X-band radar, and ground support equipment. The THAAD interceptor is comprised of a single-stage booster and kill vehicle, which destroys enemy warheads through hit-to-kill collisions. The THAAD radar is a solid-state, phased-array, X-band radar that performs search, track, discrimination, and other fire-control functions. The THAAD radar also sends updated target information to the kill vehicle while in-flight.

Background: History

The THAAD demonstration program[3] began in 1992 but was plagued by a string of flight-test failures from 1995 to 1999. As noted in an earlier report, THAAD's early failures were caused by a combination of a compressed test schedule and quality control problems.[4] Also, as reported in the Director, Operational Test and Evaluation (DOT&E) Fiscal Year 1999 Annual Report to Congress, the sense of urgency to deploy a prototype system resulted in an overly optimistic development schedule. Rather than being event driven—proceeding with development only after technical milestones were met—the program tried to keep pace with the planned schedule. Schedule

[1] MDA recently changed the name of the THAAD element to "Terminal High Altitude Area Defense."

[2] In this context, the BMD community uses the terms "missile" and "interceptor" interchangeably.

[3] The demonstration program is known formerly as the "Program Definition and Risk Reduction" (PD&RR) phase of acquisition.

[4] U.S. General Accounting Office, *THAAD Restructure Addresses Problems But Limits Early Capability*, GAO/NSIAD-99-142 (Washington, D.C.: June 30, 1999).

forces and budget cuts contributed to deficient manufacturing processes, quality control, product assurance, and ground-testing procedures, which in turn, resulted in poor design, lack of quality, and failed flight tests. The ultimate result was a schedule slip of 6 years for the deployment of the objective THAAD system.

After devoting substantial time to pretest activities, the THAAD program conducted two successful flight tests in 1999. The program then transitioned to the product development phase[5] of acquisition, in which developmental activities shifted from technology development and demonstration to missile redesign and engineering. The Department of Defense (DOD) transferred the THAAD program from the Army to the Ballistic Missile Defense Organization (now MDA) on October 1, 2001.

Background: Developmental Phases

The overarching goal of the THAAD program is to field an operational capability consisting of tens of missiles during the Block 2008 time frame. Although THAAD's development is broken out by block—2004, 2006, and 2008—each is a stepping-stone leading to the Block 2008 capability. The development efforts of each block incrementally increase element capability by maturing the hardware's design and upgrading software.

Block 2004. Block 2004 activities are expected to focus on developing and ground testing THAAD components. These tests lead to the demonstration of a rudimentary capability—an intercept capability against a short-range, threat-representative target (Flight Test 5)—at the end of Block 2004. At the end of the block, the THAAD "missile inventory" will consist of one spare missile.

Blocks 2006. By the end of Block 2006, the THAAD program will have conducted six more flight tests, five of which are intercept attempts. The flight tests scenarios are expected to include intercepts inside and outside the Earth's atmosphere. One of the five intercept attempts will be conducted employing a salvo-firing doctrine, that is, two THAAD interceptors will be launched against a single target.

[5] "Product development" is referred to as the "System Development & Demonstration" (SDD) phase of acquisition and formerly as "Engineering & Manufacturing Development" (EMD).

Blocks 2008. By the end of Block 2008, the THAAD program plans to demonstrate that the THAAD element is ready for fielding with tactical missiles, demonstrate that the element can intercept threat-representative targets (short-range and medium-range ballistic missiles), and show that THAAD can interoperate with other elements as part of the BMDS.

Progress Assessment: Schedule

The THAAD program completed most activities planned for fiscal year 2003, which were focused on contractual activities, design reviews, and subcomponent-level development and testing, leading up to flight testing beginning in fiscal year 2005.

Align THAAD with MDA Acquisition Approach: Completed Slightly Behind Schedule

During 2003, the THAAD Project Office aligned its primary research and development contract with MDA's block acquisition approach. For example, officials re-planned the contract to accommodate MDA's block strategy for developing missile defense capabilities. Because of changes in the fiscal year 2003 budget, including a funding cut of $117 million, THAAD completed its contract alignment activities slightly behind schedule. However, these activities were completed by the first quarter of fiscal year 2004. Table 30 summarizes the principal contractual activities planned for fiscal year 2003 and their actual completion date.

Table 30: Block 2004 THAAD Activities—Contract Alignment

Activity	Date completed	Comments
Contract re-planning	Nov. 2003	Delayed from Aug. 2003
Contract negotiations finalized	Dec. 2003	Delayed from Oct. 2003

Source: Missile Defense Agency.

Block 2004 Design Reviews: Completed Largely on Schedule

Since 1999, the program has conducted a number of reviews to evaluate the designs of THAAD's various components and of the element as a whole. Early reviews, known as Preliminary Design Reviews (PDRs), were conducted to evaluate the progress, technical adequacy, and risk resolution of the selected design approach; to determine their compatibility with the performance and engineering requirements of the development specification; and to establish the existence and compatibility of interfaces among other items of equipment facilities, computer programs, and personnel. Later reviews—Critical Design Reviews[6] (CDRs)—determined that the designs satisfied the performance and engineering requirements of the development specification; established the design compatibility between the component and other items of equipment, facilities, computer programs, and personnel; assessed the component's producibility and areas of risk; and reviewed preliminary product specifications.

The program successfully completed two design reviews scheduled in fiscal year 2003; the THAAD missile was the subject of both of these reviews. Tables 31 and 32 summarize all principal activities related to the verification of THAAD's Block 2004 design.

Table 31: Block 2004 THAAD Activities—Component Design Reviews

Activity	Date completed	Comments
Radar		
PDR	Feb. 1999	Completed on schedule
CDR	Sept. 2001	Completed on schedule
C2/BM		
PDR	June 2001	Completed on schedule
CDR	Aug. 2002	Completed on schedule
Launcher		
PDR	June 2002	Completed on schedule
CDR	June 2003	Completed on schedule
Missile		
PDR	June 2002	Delayed from May 2002
CDR	Sept. 2003	Completed on schedule

Source: Missile Defense Agency.

[6] A CDR may also be known as a Design Readiness Review (DRR).

Table 32: Block 2004 THAAD Activities—Element Design Reviews

Activity	Date completed	Comments
Block 2004 Element PDR	July 2002	Completed on schedule
Block 2004 Element CDR (DRR)	Dec. 2003	Completed on schedule

Source: Missile Defense Agency.

Ground Testing: Key Tests Completed in Preparation for Future Flight Testing

The THAAD program completed a number of ground tests in the fiscal year 2003 time frame. These events are listed in table 33. The program office characterized these tests as key events in preparation for Block 2004 flight testing.

Table 33: Block 2004 THAAD Activities—Ground Testing

Major test event	Date	Comments/Test objectives
Booster Motor Test	Sept. 2002	Objectives achieved—Static fire of the THAAD solid propellant booster motor
Radar Transmit/Receive Module Test	Jan. 2003	Objectives achieved—T/R module qualification testing
Divert and Attitude Control System (DACS) Thruster Testing	Mar. 2003	Objectives achieved—First hot fire test of a DACS thruster
Missile Separation Effects Tests	Aug. 2003–Sept. 2003	Objectives achieved—Verify structural integrity and stability of the missile with separation events (booster separation and shroud separation)
Kill Vehicle Destruct Test	Oct. 2003	Objectives achieved—Test of kill vehicle flight termination system

Source: Missile Defense Agency.

THAAD Flight Test Program

The THAAD flight test program consists of 16 flight test events divided among Blocks 2004, 2006, and 2008. The first two of the five planned Block 2004 flight tests are referred to as control test flights (CTF)—non-intercept tests that focus on how the missile operates under stressful environmental conditions. The third flight test is a seeker characterization flight (SCF), which ensures proper functioning of the seeker in a live intercept environment. This is a non-intercept test as well, but targets are involved. The fourth test, flight test 4 (FT-4), is the first intercept attempt at

White Sands Missile Range (WSMR)[7] with a configuration—target and engagement geometry—comparable to the flight tests during the Program Definition and Risk Reduction phase of development. Block 2004 flight test activities end with a second intercept attempt (FT-5), conducted at Pacific Missile Range Facility (PMRF),[8] against a threat-representative target. The program office plans to consume all procured missiles in flight tests. However, because there will be five flight tests in Block 2004 and THAAD has plans to procure six test missiles, one missile will be available as a spare. THAAD program office officials also noted that test missiles could be used for emergency operational use, rather than as test assets, if needed. Table 34 summarizes Block 2004 flight test events, including dates and objectives.

Table 34: Block 2004 THAAD Activities—Flight Testing

Flight test event	Date	Objectives
FT-1 (CTF) at WSMR	1Q FY 2005	• Validate missile performance in a high-endoatmospheric flight environment • Verify missile integration with WSMR
FT-2 (CTF) at WSMR	2Q FY 2005	• Characterize missile performance in a low- endoatmospheric flight environment • Effects of heat on seeker window • High dynamic pressure fly-out
FT-3 (SCF) at WSMR	3Q FY 2005	• Seeker characterization flight against a high- endoatmospheric target • Verify element integration with WSMR
FT-4 at WSMR	4Q FY 2005	• Demonstrate exoatmospheric discrimination and intercept of a separating target • Demonstrate lethality assessment of recovered debris
FT-5 at PMRF (Now called FTT-04-01)	1Q FY 2006	• Demonstrate exoatmospheric aimpoint selection and intercept against a non-separating liquid-fueled target • Demonstrate integration with PMRF

Source: Missile Defense Agency.

Note: Test schedule as of December 2003.

Flight-test conditions are grouped by block. For example, Block 2004 tests focus on engagements outside the atmosphere (exoatmospheric), whereas the first intercept attempt inside the atmosphere (endoatmospheric)

[7] White Sands Missile Range is a U.S. Army missile test range in New Mexico.

[8] Pacific Missile Range Facility is a U.S. Navy missile test range in Kauai, Hawaii.

occurs in Block 2006. The level and sophistication of testing achieved to that point defines the capability of the THAAD element at a given time.

Finally, deliveries of THAAD boosters could be jeopardized by explosions at Pratt & Whitney's propellant mixing facility[9] that occurred during the summer of 2003. According to updated test schedules, these incidents have already delayed the first non-intercept flight test, Control Test Flight 1, by 3 months. However, the program office expects to maintain the schedule for the first intercept attempt, FT-4, currently scheduled for the fourth quarter of fiscal year 2005. To mitigate schedule risk, the program office enlisted Aerojet as the replacement vendor for Pratt and Whitney's propellant mix and cast operations. We note that this Pratt & Whitney facility also provides rocket motors for the Aegis BMD and GMD programs.

Progress Assessment: Performance

Data collected during element-level flight testing will be used to "anchor" end-to-end simulations of THAAD operation. Until these simulations are properly validated and verified, one cannot be confident of any quantitative assessment of the element's effectiveness for terminal defense. Nonetheless, the program office told us that all performance indicators predict that THAAD is on track to meet operational performance goals.

Program Assessment: Cost

MDA expects to invest about $4.3 billion from fiscal year 2004 through 2009 in the development and enhancement of the THAAD element. This is in addition to the $1.47 billion expended in fiscal years 2002 and 2003.

Most of the THAAD budget goes to fund the element's prime contract. The contractor reported that its fiscal year 2003 work cost slightly more than budgeted and that it was somewhat behind schedule. Specifically, the work cost about $12 million more than expected, and the contractor could not complete approximately $12.2 million of the work scheduled for the fiscal year.

[9] The program office refers to these incidents as "energetic release incidents." The incidents occurred at Chemical Systems Division (CSD), a subsidiary of Pratt and Whitney, a THAAD contractor.

Program Cost: THAAD Program Costing Approximately $710 Million per Year

The program estimates that it will need about $4.3 billion over the next 6 years to continue THAAD's development. This includes funds for Blocks 2004, 2006, and Block 2008. Program costs prior to THAAD's transfer to MDA at the beginning of fiscal year 2002 amounted to approximately $4.9 billion. In fiscal years 2002 and 2003, the program expended an additional $1.6 billion, bringing the total investment in THAAD between the program's inception and 2003 to about $6.5 billion. Table 35 shows the expected THAAD program costs by fiscal year from 2004 through 2009, the last year for which MDA published its funding plans.

Table 35: THAAD Planned Cost

Dollars in millions of then-year dollars

	Fiscal year						
Block	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Block 2004	$687	$593	$154	$0	$0	$0	**$1,434**
Block 2006	29	239	535	791	91	0	**1,685**
Block 2008	0	2	204	232	389	324	**1,151**
Total	**$716**	**$834**	**$893**	**$1,023**	**$480**	**$324**	**$4,270**

Source: Missile Defense Agency.

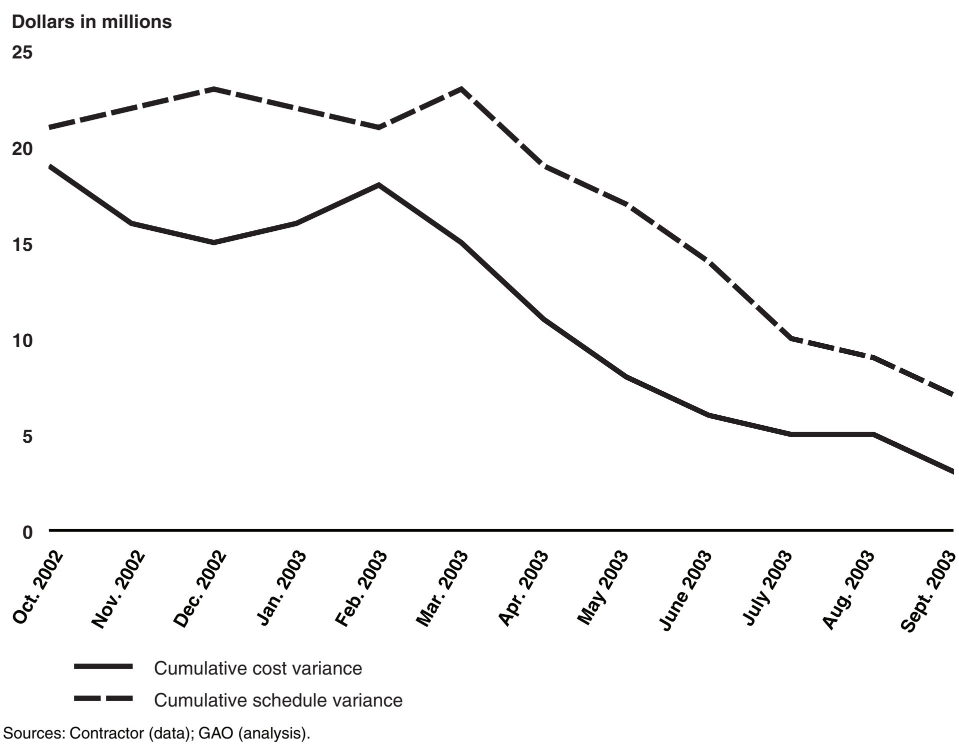
Prime Contractor Fiscal Year 2003 Cost and Schedule Performance: Declining Performance Erodes Positive Variances

The THAAD prime contract consumes the bulk of the program budget: an average of 70 percent is allocated to the prime contractor team and 30 percent is allocated to the government for Block 2004 efforts. The contract has undergone re-planning to re-phase the work according to blocks. As indicated in table 30, the re-planning was completed in November 2003, and contract negotiations were finalized in December 2003. THAAD's prime contract is held by Lockheed Martin Space Systems in Sunnyvale, California; Lockheed also manages the missile's development.

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—activities costing less or completed ahead of schedule—are generally considered as good news and negative variances—activities costing more or falling behind schedule—as bad news.

The THAAD prime contract continued to carry a positive cost and schedule variance during fiscal year 2003. However, as figure 11 shows, the contractor's positive cost and schedule variance eroded somewhat during fiscal year 2003: the contractor's work cost about $12.0 million more than budgeted, and the contractor could not complete approximately $12.2 million worth of work scheduled during this time. The unfavorable cost variance was driven by the missile component but partially offset by other components. However, with 49% of the THAAD contract completed, the prime contractor is, overall, under budget and ahead of schedule.

Figure 11: Fiscal Year 2003 Cost and Schedule Performance



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

The contractor experienced difficulties with missile development, which accounts for 35 percent of the contract's total cost. In fiscal year 2003, work on missile development cost approximately $11 million more than budgeted. According to MDA's analysis, propulsion subsystem development, particularly problems with the development of the Divert and

Attitude Control System, has been the driver for missile development cost overruns.

The prime contractor estimates that the entire contract will be completed slightly under budget.[10] However, in order to finish the work effort within budget, the contractor needs to work as efficiently as it did in the previous fiscal years. In our opinion, the contractor's estimate is somewhat optimistic, considering the contractor's trend of declining performance and because approximately 5 years of work remain on this contract. According to our analysis of the contractor's data, the contractor has been completing, on average, $0.97 worth of scheduled work for every budgeted dollar spent to accomplish that scheduled work during fiscal year 2003. On the basis of this efficiency rate, we estimate that the contract will overrun its budget at completion by between $23 million and $65 million.

Program Risks

On the basis of our assessment of fiscal year 2003 activities, we did not find any evidence of key risks that could affect MDA's ability to develop, demonstrate, and field the THAAD element within schedule estimates. However, it is too early to state with confidence whether the element will or will not be ready for integration into the BMDS during the Block 2008 time frame, especially since flight testing has not yet begun. Unsuccessful intercept attempts could delay the program and increase its cost, as was the case during THAAD's Program Definition and Risk Reduction phase of the 1990s.

[10] In September 2003, the prime contractor estimated that the contract would be completed approximately $0.7 million below the budgeted cost.

Fiscal Year 2002 Assessment

The National Defense Authorization Act for Fiscal Year 2003 directed the Department of Defense (DOD) to establish cost, schedule, testing, and performance goals for its ballistic missile defense programs for the years covered by the Future Years Defense Plan. In the act, Congress also directed us to assess the extent to which the Missile Defense Agency (MDA) achieved these goals each in fiscal years 2002 and 2003. We were unable to fulfill this mandate in fiscal year 2002 because MDA had not established such goals.

As an alternative, we began to assess the tools that MDA uses as part of the agency's management process to monitor cost, schedule, and performance progress. In February 2003, we briefed the staff of the Congressional addressees of this report on our initial findings. However, we were unable to complete this assessment, because some of the tools were evolving and others had been only partially implemented.

MDA identified four tools it uses to monitor progress: the Integrated Master Plan (IMP), the Integrated Master Schedule (IMS), the Earned Value Management System (EVMS), and Technical Performance Measures (TPM). The IMP[1] identifies essential actions that must be completed to successfully deliver a block of BMDS capability. Between our review in September 2002 and June 2003, the document remained in draft form and evolved from a generic checklist of activities into a template focused on the specific activities needed to deliver a particular block. In June 2003, MDA amended the draft BMDS IMP to reflect the President's direction of December 2002 to begin fielding the Block 2004 system.

Similarly, the IMS was evolving. The purpose of the IMS is to plot the expected date of activities that must be completed to achieve a block of capability. MDA altered the IMS because the capability being developed in Block 2004 changed from the delivery of a test bed to the delivery of a fielded capability.

The EVMS, which tracks whether the contractor is performing work within budgeted cost and schedule, was only partially implemented at the time of our fiscal year 2002 review. Many of the element prime contracts were being modified to reflect MDA's new block strategy, and the contractors could not report progress toward Block 2004 until the contractor could

[1] U.S. General Accounting Office, *Knowledge-Based Practices Are Being Adopted, but Risks Remain*, GAO-03-441 (Washington, D.C.: April 30, 2003).

develop a program performance baseline against which cost and schedule performance could be measured.

Finally, MDA had only partially implemented the tracking of TPMs—parameters of system, element, and component effectiveness—as part of its program management process. Specific elements such as GMD had tracked TPMs, but as noted by program officials, MDA had just begun to develop system-level TPMs.

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