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Report to Congressional Requesters

February 2004

MISSILE DEFENSE

Actions Being Taken to Address Testing Recommendations, but Updated Assessment Needed

GAO-04-254

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Highlights

Highlights of GAO-04-254, a report to Congressional Requesters

Why GAO Did This Study

In August 2000, the Defense Department 's (DOD) Director, Operational Test and Evaluation (DOT&E), made 50 recommendations on a test program for a system to defeat long-range ballistic missile threats against the United States. DOD's Missile Defense Agency (MDA) plans to begin fielding the system by September 2004.

GAO examined (1) how MDA addressed DOT&E's recommendations and (2) what is known about the effectiveness of the system to be fielded by September 2004. GAO issued a classified report on this subject in June 2003. This unclassified, updated version reflects changes in MDA's test schedule.

What GAO Recommends

GAO recommends DOT&E report on the status of MDA's responses to its recommendations and advise MDA how to modify the test program to address long-standing concerns. DOD agreed with these recommendations, while noting there have been many changes in its test program and its acquisition strategy and structure since DOT&E's August 2000 report. GAO revised the report to reflect the latest, approved test program but believes most DOT&E recommendations remain relevant given the significant technical challenges and uncertainties facing MDA.

www.gao.gov/cgi-bin/getrpt?GAO-04-254.

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

What GAO Found

MDA is addressing most of DOT&E's recommendations on flight testing but will not complete many actions before September 2004. For example, DOT&E recommended removing flight test range limitations by adding more intercept regions and launch locations to add greater realism to its tests. MDA is expanding the test range infrastructure to add five intercept regions and target and interceptor launches out of new locations. By September 2004, one of the regions will be tested.

MDA is generally not addressing DOT&E's proposals on ground testing. For example, although MDA had begun upgrading a ground facility to provide a realistic testing environment for the interceptor, MDA deferred testing at the facility to fund other priorities. Finally, MDA is addressing DOT&E's recommendations on discrimination--the system's ability to find an enemy warhead among decoys--by funding analysis programs.

Predictions of how well the system will defeat long-range ballistic missiles are based on limited data. No component of the system to be fielded by September 2004 has been flight-tested in its deployed configuration. Significant uncertainties surround the capability to be fielded by September: MDA will not demonstrate in flight tests a critical radar called Cobra Dane before that date or conduct a system-level demonstration, and has yet to test its three-stage boosters as part of a planned intercept.

GMD Interceptor

Source: Ground-Based Midcourse Defense Program Office.

Contents

Abbreviations

BMDO	Ballistic Missile Defense Organization
BMDS	Ballistic Missile Defense System
CHOP	Countermeasures Hands-On Program
DOD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
DRR	Deployment Readiness Review
EKV	Exoatmospheric Kill Vehicle
FY	fiscal year
GMD	Ground-based Midcourse Defense
GPS	Global Positioning System
HWIL	Hardware in the Loop
IFICS	In-Flight Interceptor Communications System
IFT	Integrated Flight Test
IOC	Initial Operational Capability
LFT&E	Live Fire Test and Evaluation
LIDS	Lead System Integrator (LSI) Integrated Distributed Simulation
MDA	Missile Defense Agency
NMD	National Missile Defense
NSPD	National Security Presidential Directive
OPINE	Operations in the Nuclear Environment
ORD	Operational Requirements Document
UEWR	Upgraded Early Warning Radar

GAO
Accountability * Integrity * Reliability

United States General Accounting Office
Washington, DC 20548

February 26, 2004

The Honorable Henry A. Waxman
Ranking Minority Member
Committee on Government Reform
House of Representatives

The Honorable John F. Tierney
House of Representatives

The Missile Defense Agency (MDA) within the Department of Defense (DOD) is developing and testing components of the Ground-based Midcourse Defense (GMD) element, which is intended to defeat long-range ballistic missile threats in the midcourse phase of flight.[1] When deployed, GMD will include (1) space- and ground-based sensors to provide early warning and tracking of missile launches; (2) ground- and sea-based radars to identify and refine the tracks of threatening missiles (called reentry vehicles) and associated objects; (3) ground-based interceptors, each consisting of a three-stage booster and kill vehicle, to destroy enemy missiles through "hit-to-kill" impacts outside the atmosphere; and (4) fire control nodes for battle management and execution of the GMD mission.

In August 2000, the Director, Operational Test and Evaluation (DOT&E), submitted a report to the Under Secretary of Defense for Acquisition, Technology, and Logistics for consideration at DOD's deployment readiness review for the National Missile Defense system.[2] The purpose of the report was to provide an independent assessment of the system's potential operational effectiveness and suitability. Based on its assessment of the system at that time and the adequacy of testing in the context of

[1] The midcourse phase of flight refers to that portion of a ballistic missile's trajectory between the boost phase and reentry phase when the warheads and decoys travel on ballistic trajectories above the atmosphere.

[2] DOT&E is responsible for providing independent oversight of testing of major DOD acquisition programs to ensure that operational test and evaluation of major defense programs is adequate for verifying 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 advice to responsible officials on developmental testing.

deployment, it stated that test results supported a decision to continue development but not deployment. In the report, DOT&E stated that the current test program required augmentation and probably significant funding increases to demonstrate an operationally effective system for deployment. The report included a list of 50 detailed recommendations regarding the test program. In September 2000, the President decided to defer the deployment decision to the next administration, and MDA (then named the Ballistic Missile Defense Organization) continued with development of the system.

In January 2002, the Secretary of Defense refocused the ballistic missile defense program into a broad-based research and development effort managed by MDA. The new program follows a "capability-based approach" and aims at developing layered defenses to intercept missiles in all phases of flight. According to MDA, such an approach adds flexibility to the acquisition process by permitting the development and testing of mature technologies for the quick delivery of some capability. The new approach also allows DOD to evolve and demonstrate additional improvements in missile defense systems before committing to procurement and operations. To this end, MDA is following a "block" approach, which defines, develops, produces or acquires, and fields operational capability in incremental blocks. Each block is designed to build capability into the system by introducing new or improved technology. The first block—Block 2004—in this approach to offer a defensive capability builds upon MDA's Ballistic Missile Defense System (BMDS) Test Bed for conducting more realistic testing of ballistic missile defense elements, of which GMD is the centerpiece.

In December 2002, the President directed DOD to begin fielding components of the ballistic missile defense system for operational use by 2004. That is, in addition to focusing resources on the development of the BMDS Test Bed for developmental testing of missile defense elements, he instructed MDA to build in an initial defensive capability that would protect the United States against long-range missile attacks. The Secretary of Defense stated that "…it would be a very preliminary, modest capability." DOD decided to begin fielding an initial capability by September 2004.

Because of the significance of recommendations made by DOT&E during DOD's deployment readiness review and the decision by the President to deploy an initial defensive capability, you asked us to examine (1) the actions taken or planned by MDA that address the recommendations made by DOT&E, and (2) what is known about the effectiveness and limitations

of the initial defensive capability to defeat long-range ballistic missiles in the September 2004 time frame. The scope and methodology for our review is included in appendix I.

We provided you with a classified report on this subject in June 2003. This is an unclassified version of that report, which has also been updated as of December 2003 to reflect changes in the GMD test program. In preparing this unclassified version, we removed details on some of our findings after an extensive declassification process. These details can be found in the classified version of the report. The current version has been reviewed by the DOD and approved for public release.

Results in Brief

Of the recommendations listed in the August 2000 DOT&E report—which we grouped under flight testing, ground testing, target discrimination, and programmatics categories—MDA is taking actions that, over time, address most of the flight testing recommendations but, by contrast, substantially fewer of the remaining recommendations. Specifically,

- MDA is addressing most of the DOT&E's recommendations on flight testing but will not complete many actions before September 2004. For example, DOT&E recommended the removal of flight test range limitations by adding more intercept regions and launch locations to achieve new intercept geometries, higher closing velocities, and longer ranges flown by the interceptor. MDA is expanding the test range infrastructure through the development of the Test Bed to add five intercept regions and target and interceptor launches out of new locations. By September 2004, MDA will have tested in one of the five new intercept regions. Other DOT&E recommendations on enhanced realism and the elimination of artificialities in flight tests are being acted upon by MDA, but full realization will take time to complete.
- MDA is generally not addressing DOT&E's recommendations on ground testing. For example, although MDA had taken steps to proceed with the design and construction of a hardware-in-the-loop laboratory at the Arnold Engineering Development Center in Tennessee, comprehensive testing of the kill vehicle in this facility has been deferred beyond Block 2004 because of funding constraints. However, lethality testing for GMD engagements on the ground has been enhanced with investments in the Hypersonic Upgrade Program facility at Holloman Air Force Base.
- MDA is generally addressing DOT&E's recommendations on discrimination—the system's ability to identify the true reentry vehicle from among decoys and associated objects. MDA has substantially increased the scope of work being done in discrimination, but MDA's flight tests planned through September 2007 are not designed to address the

challenge posed by the certain countermeasures that DOT&E identified as simple for an enemy to implement. MDA maintains that the complexity and challenge of target suites used in integrated flight tests will increase as the discrimination capability is incrementally proven.

The predicted effectiveness of the initial defensive capability to defeat long-range ballistic missiles is currently based on a limited set of flight-test data. For example, none of the components of the initial defensive capability to be fielded in September 2004—interceptors, fire control nodes for battle management and execution, upgraded radars, and forward-deployed Aegis radars on Navy cruisers and destroyers—has been flight-tested in its deployed configuration. As such, current predictions of effectiveness are based on analysis and simulations of expected performance of constituent components. The most significant uncertainties surrounding the capability to be fielded in September 2004 are (1) MDA does not plan to demonstrate capabilities of a critical radar for use with the GMD element, called Cobra Dane, in flight tests before that date; (2) MDA has yet to test both three-stage boosters as part of an attempted intercept; and (3) MDA does not plan to conduct a system-level demonstration of the initial defensive capability in flight testing before September 2004. Furthermore, a notable limitation of system effectiveness is the inability of system radars to perform rigorous target discrimination. The Cobra Dane radar and the upgraded early warning radar in California can perform rudimentary target discrimination, but the kill vehicle itself must perform final target selection during the endgame.

The recommendations in this report also appeared in our classified June 2003 report. We have made these recommendations to provide decision makers DOT&E's assessment of MDA's actions related to concerns raised by DOT&E's August 2000 report. In commenting on a draft of our June 2003 report, DOD agreed with our recommendations. The department raised concerns, however, that the GMD test program as described in this report is no longer current and the program strategy and structure have changed since DOT&E submitted its report. While the GMD test program has, indeed, been in a constant state of flux, thus complicating our analysis, our report presents the latest, approved test program information provided to us by MDA. Also, despite alterations to the acquisition strategy and structure of the ballistic missile defense system, we believe most of the DOT&E recommendations are still relevant because the technical challenges and uncertainty with developing, testing, and fielding effective defensive capabilities, as identified in the August 2000 DOT&E report, remain significant.

Missile Defense Agency Actions Taken or Planned to Address DOT&E Recommendations

The August 2000 DOT&E report summarized the progress, up to that date, of the National Missile Defense program and the adequacy of testing in the context of a deployment decision.[3] At the time, the development program revolved around a series of ground and flight tests and was to have culminated in an initial operational capability by the end of fiscal year 2005. Formal test documentation called for a total of 16 integrated flight tests (system-level intercept attempts) through 2004 with three additional flight tests during Initial Operational Test and Evaluation during the 2005 fiscal year. DOT&E's principal finding was that ground and flight tests completed up to that time did not provide results of sufficient fidelity to support a deployment decision. Indeed, when the deployment readiness review was held, there had been two failed intercepts out of three attempts. Furthermore, as stated in the DOT&E report, ground testing was not adequate to yield credible estimates of GMD system performance. DOT&E indicated that the current test program required augmentation and probably significant funding increases to demonstrate an operationally effective system for deployment. Accordingly, the report included a list of detailed recommendations for enhancing the test program.

DOT&E made 50 specific, interrelated recommendations, which we organized into the following four overarching categories: Flight Testing, Ground Testing, Target Discrimination,[4] and Programmatics. Although DOT&E categorized discrimination-related recommendations under the flight-testing and ground-testing categories, we created a separate category because discrimination was of principal concern to DOT&E at the time. DOD classified the full text of the recommendations. A detailed assessment indicating whether actions have been initiated by MDA and what their timing is relative to the September 2004 initial defensive capability date can be found in our June 2003 classified report on this subject. A summary of MDA actions to address the DOT&E recommendations is provided below.

DOT&E Recommendations on Flight Testing

Integrated flight tests of the GMD element are demonstrations of system performance during which an interceptor is launched to engage and intercept a target reentry vehicle (mock warhead) above the atmosphere.

[3] The National Missile Defense program is now referred to as the Ground-based Midcourse Defense (GMD) program, terminology we use from this point on.

[4] Target discrimination is the identification of the true reentry vehicle from among decoys and associated objects.

Many recommendations (20 of 50) in the DOT&E report pertain to aspects of integrated flight testing, such as deficiencies in flight-test complexity, operational realism, and artificialities. DOT&E's concerns with the composition of target suites in flight tests for testing discrimination are discussed separately in the discrimination section of this report. DOT&E reported that increasing the scope of flight testing was essential to stress the limits of system design and to keep pace with system development.

MDA is taking actions that address many of the shortcomings in flight testing DOT&E identified in its August 2000 report. Indeed, the development of the BMDS Test Bed—the agency's key instrument for enhancing the existing test infrastructure to provide more realistic testing—should go far in addressing these DOT&E recommendations over the long term. Currently, flight tests are limited to target launches out of Vandenberg Air Force Base, California, and interceptor launches out of Kwajalein Missile Range in the western Pacific.[5] For enhancing the capabilities of integrated flight testing, the test bed adds an interceptor launch site at Vandenberg Air Force Base; target launch facilities at Kodiak Launch Complex, Alaska; a GMD fire control node at Fort Greely, Alaska; an upgraded early warning radar at Beale Air Force Base, California; upgraded communication links among test bed components; and test infrastructure to support five additional intercept regions. The ship-based Aegis AN/SPY-1 radar is also available as a forward-deployed asset for early target tracking. In addition, the design and construction of a sea-based X-band radar, which would be positioned on a mobile platform in the Pacific, has been funded by MDA and is scheduled to be available for test bed utilization in late 2005. Other components of the BMDS Test Bed such as the Cobra Dane radar in Shemya, Alaska, and interceptors at Fort Greely will not actively participate in integrated flight tests at least through September 2007.

Flight Test Complexity

Several August 2000 DOT&E recommendations call for integrated flight testing with Category B engagements[6] and scenarios with multiple threatening reentry vehicles, both of which are expected to be common

[5] Kwajalein Missile Range is now referred to as Reagan Test Site, terminology we use from this point on.

[6] The GMD system is designed to launch interceptors under one of three "categories" of operation: (A) when a threat reentry vehicle has been tracked and discriminated by ground-based radars; (B) when ground-based radars have a track of the threat complex but discrimination is either incomplete or unavailable; or (C) when space-based sensors provide an early track of the boosting missile.

during operational missions. In addition, the recommendations call for integrated flight testing to be performed under increasingly difficult conditions and to be made more challenging through, for example, testing under various solar and weather conditions. Our analysis of the GMD test program as it pertains to flight test complexity, based on the March 2003 Developmental Master Test Plan for the GMD element and related program documentation, is summarized below.

- **Flight Test Complexity—Actions Taken or Planned.** The GMD test plan calls for Category B engagements beginning with Integrated Flight Test 15 (IFT-15), scheduled for the fourth quarter of fiscal year 2004. Furthermore, it indicates that Category B engagements would be a common occurrence of flight testing, because the weapon task plan[7] would be generated from Beale or Aegis radar data. According to MDA officials, however, the decision to conduct future flight tests under Category B engagements is currently under review; the resolution will depend on the individual flight test scenario and the maturity of battle management assets. The GMD Developmental Master Test Plan also shows that an integrated flight test (designated IFT-22/23) in which two interceptors are launched against two attacking reentry vehicles (multiple simultaneous engagements) will be carried out in fiscal year 2007.
- **Flight Test Complexity—Actions Not Taken or Planned.** Although previous flight tests have been conducted under limited adverse conditions (light rain), flight tests to assess the actual effects of severe weather on system performance are not currently planned. According to the program office, the verification of system performance in adverse weather will be achieved through modeling and simulation grounded in technical measurements and flight test data. Furthermore, a nighttime engagement was attempted during IFT-10 (December 2002), but the failure of the kill vehicle to separate from the surrogate booster precluded collection of any applicable data.

Operational Realism

The recommendations on operational realism reflect limitations of the current test range. Currently, intercept tests are constrained to a single corridor and intercept region—target launches out of Vandenberg Air Force Base and interceptor launches out of the Reagan Test Site. As a result, flight-test engagement conditions are limited to those with low closing velocities and short interceptor fly-out ranges. DOT&E called for

[7] A weapon task plan consists of pre-launch instructions for generating an interceptor flyout solution that places it on an intercept path with the target. Such a plan is required before an interceptor is launched.

an expansion of engagement conditions and suggested adding more intercept regions and launch locations to achieve new intercept geometries, higher closing velocities, and longer ranges flown by the interceptor during flight testing.

- **Operational Realism—Actions Taken or Planned.** The expansion of the test range in the Pacific with the development of the BMDS Test Bed will have a significant impact on achieving operational realism in integrated flight tests. The Block 2004 Test Bed adds five intercept regions, target launches out of Kodiak Launch Complex, and interceptor launches out of Vandenberg Air Force Base. The combination allows for flight tests with new intercept geometries, additional crossing angles, higher closing velocities, and longer ranges flown by the interceptor. For example, IFT-15 (fourth quarter of fiscal year 2004) will be conducted with a target launch out of Kodiak, and IFT-17 (fourth quarter of fiscal year 2005) will be the first test with an interceptor launched from Vandenberg.
- **Operational Realism—Caveats.** The principal caveat to the associated MDA actions addressing operational realism is timing. By September 2004, one of the five new intercept regions, north of Reagan Test Site, will have been exercised. The remaining new intercept regions will not be exercised until after September 2004. For example, the two intercept regions off the west coast of the United States will be used in IFT-17 (fourth quarter of fiscal year 2005) and IFT-18 (fourth quarter of fiscal year 2005), respectively. A fourth intercept point will be exercised in IFT-21 (third quarter of fiscal year 2006). Finally, the fifth intercept point will be exercised as part of the multiple simultaneous engagement to be conducted in fiscal year 2007.

Artificialities

The DOT&E recommendations on flight test artificialities—such as the removal of surrogates (test range assets emulating operational assets)—also reflect limitations of the current test range. The most artificial surrogate noted in the August 2000 DOT&E Report was the placement of a C-band transponder[8] on the target reentry vehicle. The transponder was essential for the execution of flight tests, because in conjunction with the test range radar (designated FPQ-14[9]), there were no other non-artificial options available to track the reentry vehicle with sufficient accuracy for

[8] MDA defines a transponder as a "receiver-transmitter that will generate a reply signal under proper interrogation." The missile defense community also refers to the transponder as the "C-band beacon."

[9] FPQ-14 is a C-band test-range radar located in Oahu, Hawaii.

executing the mission. DOT&E argued that this artificiality be phased out and, in general, recommended the system utilized in integrated flight tests be as functional and representative as possible.

- **Artificialities—Actions Taken or Planned.** Use of the transponder/FPQ-14 radar combination as a surrogate radar for midcourse tracking is planned to be phased out. Indeed, IFT-15 (fourth quarter of fiscal year 2004) would be the first test that does not use this surrogate for mission execution. Rather, in integrated flight tests IFT-15 and beyond, midcourse tracking of the target suite would be achieved through the use of the Beale upgraded early warning radar or, pending ongoing analysis by GMD, the Aegis SPY-1 radar. The eventual use of the sea-based X-band radar beginning in late 2005 can also be used for midcourse tracking. The removal of other surrogates is under way. For example, the short-range surrogate interceptor booster, which has been used in all flight tests to date, is scheduled to be replaced with two more operationally representative boosters beginning with IFT-14 (third quarter of fiscal year 2004).
- **Artificialities—Actions Not Taken or Planned.** The MDA is not currently considering conducting flight tests under unrehearsed and unscripted conditions.

Elimination of Flight Tests

Overall, the current DOT&E has looked favorably on MDA's actions that address its recommendations, because the GMD test infrastructure is being significantly enhanced to allow for more flight test complexity, operational realism, and artificialities. We noted, however, that since DOT&E's August 2000 assessment, MDA has reduced the extent of the flight test program, as follows:

- **Integrated Flight Tests—Number of Cancellations.** During the initial planning phases of the revised test program, MDA considered conducting four intercept attempts per year. But after considerable planning and contract evaluations, MDA limited the flight test program to no more than three intercept attempts per year because of overlapping test objectives and funding constraints. Significantly, the previous GMD test program at the time of the deployment readiness review called for a total of 19 integrated flight tests to be carried out through fiscal year 2005. The current test program, however, now has a total of 12 integrated flight tests through fiscal year 2005—because of the cancellation of IFT-11, 12, and 16, and the conversion of IFT-13 to booster tests (IFT-13A and 13B). To date, 8 of the 12 have been completed under largely the same test conditions that were critically assessed by DOT&E. In short, only two flight tests under improved test conditions with more representative hardware are planned

to be conducted before September 2004, the time at which the initial defensive capability is scheduled to become available.

- **Operational Testing—No Longer Required.** The previous GMD test program also called for operational testing—Initial Operational Test and Evaluation—by the military services. Operational testing is a statutory requirement for DOT&E to independently determine operational effectiveness and suitability of a deployed system for use by the warfighter. MDA does not plan to operationally test the Block 2004 GMD element before it is available for initial defensive operations. The September 2004 fielding is not connected with a full-rate production decision that would clearly trigger statutory operational testing requirements. Nonetheless, the Combined Test Force, a group of users and developers, plans tests to incorporate both developmental and operational test requirements in the test program.

DOT&E'S Recommendations on Ground Testing

The 13 ground testing recommendations formulated by DOT&E in its August 2000 report are focused concerns encompassing four areas: (1) realistic testing of kill vehicle functions in a Hardware-in-the-Loop (HWIL) facility,[10] (2) ground-based lethality testing, (3) development of the system-level simulation known as the Lead System Integrator Integration Distributed Simulation (LIDS), and (4) Operations in a Nuclear Environment (OPINE) testing of kill vehicle components. In general, DOT&E's recommendations on ground testing are not being addressed.

Hardware-in-the-Loop Testing

A number of the August 2000 DOT&E ground testing recommendations pertain to the hardware-in-the-loop testing of the kill vehicle built by Raytheon. For example, a test article is placed in an evacuated chamber to simulate an exoatmospheric environment, and infrared radiation of a simulated target scene is projected onto the kill vehicle's sensors. DOT&E recommended "that an innovative new approach needs to be taken towards hardware-in-the-loop testing of the kill vehicle, so that potential design problems or discrimination challenges can be wrung out on the ground in lieu of expensive flight tests." DOT&E stated that, in order to verify kill vehicle performance, kill vehicle testing should be executed using actual unit hardware in a hardware-in-the-loop facility capable of providing a realistic space environment and threat scene. MDA had taken steps to proceed with the design and construction of a hardware-in-the-loop laboratory at the Arnold Engineering Development Center, Tullahoma, Tennessee. Although an initial test capability had been

[10] Hardware-in-the-loop testing is the high fidelity ground testing of a test article in a realistic yet simulated environment.

planned for the 2004 time frame, testing at the Arnold Engineering facility has been deferred beyond Block 2004 based on Test Bed funding constraints. In response to a draft of this report, MDA stated that future investments and test events at this facility are subject to MDA internal management trade-offs among the numerous priorities associated with the whole missile defense program portfolio.

Lethality Testing

DOT&E made recommendations in its August 2000 report for improving GMD lethality testing—testing aimed at assessing a kill vehicle's effectiveness in destroying a reentry vehicle. Current test plans call for an approach whereby ground-based experiments are conducted to collect data to anchor simulations, which in turn are used to assess lethality performance. Indeed, GMD expects to anchor such simulations from data derived from improved "sled testing," which uses full-scale targets in the newly developed Holloman Air Force Base Hypersonic Upgrade Program facility. However, there are no plans to conduct intercept flight tests of the interceptor's ability to destroy threat representative targets that fulfill the Live Fire Test and Evaluation requirements. Rather, hit point information is collected from actual intercept tests, which, in turn, is used as input to simulations to determine whether the impact was lethal.

LIDS

Another area of ground testing recommendations identified in the August 2000 DOT&E report concerned the development and use of system-level digital simulations. During the time of the deployment readiness review, the prime contractor's principal tool for assessing system performance over a broad range of scenarios was the end-to-end digital simulation known as LIDS. Because the development of the simulation was behind schedule and unavailable to support analyses of overall system performance, DOT&E reported that results obtained from it should not be used in making a deployment decision. DOT&E recommended that LIDS capability be "evolved to a fully validated, high-fidelity simulation." In addition, DOT&E recommended that LIDS be made flexible enough to permit independent use by test agencies. MDA disagrees with the recommendations pertaining to LIDS. MDA views LIDS as one of many tools to analyze performance aspects of the GMD element and does not believe that LIDS needs to be developed to the level expected by DOT&E. According to the agency, a baseline of models and simulations are available that are intended to collectively support the entire range of analysis required to verify the capabilities of the GMD elements. Furthermore, MDA asserts the evolution of LIDS from Software Build 4 to its current Software Build 6.1.0 has improved the flexibility of the system to allow for sensitivity analyses by government users. According to MDA,

extensive analysis using LIDS has been conducted at the Joint National Integration Center at Shriever Air Force Base, Colorado.

OPINE Testing

Finally, the remaining ground testing recommendations identified in the August 2000 DOT&E report focus on OPINE testing, which refers to the operation of individual GMD components in environments induced by nuclear explosions. Details can be found in the classified version of this report.

DOT&E Recommendations on Target Discrimination

Target discrimination is a critical function of a missile defense engagement that requires the successful execution of a sequence of functions, including target detection, target tracking, estimations of physical characteristics of tracked objects, and data fusion. DOT&E had two overarching concerns with the operational testing of the discrimination function:

- **Capability against diverse threats.** Fundamentally, successful target discrimination requires that the defense be able to anticipate many characteristics of the threat. DOT&E, therefore, was concerned that discrimination algorithms may not be sufficiently robust to handle unanticipated threat scenes.
- **The quality and quantity of information known prior to testing.** DOT&E was concerned that every physical property of target objects is known with unrealistic accuracy in advance of flight tests.

Twelve of 50 recommendations in the August 2000 DOT&E report pertain to the testing of the discrimination function. Specifically, DOT&E recommended adding challenging yet unsophisticated countermeasures to the target suites of integrated flight tests. DOT&E also recommended integrating countermeasures developed by the Countermeasures Hands-On Program[11] (CHOP) into target suites of integrated flight tests. Finally, DOT&E recommended executing flight test events—either intercept attempts or risk reduction flights—that have a "pop quiz" component with respect to radar discrimination. Operationally, this type of flight test is

[11] The CHOP program, based at the U.S. Air Force Phillips Laboratory at Kirtland Air Force Base in New Mexico, is an MDA-funded program chartered to develop, build, and test countermeasures using only technology available to emerging missile states. The program involves young scientists, engineers, and military officers who are not specifically trained in missile defense or countermeasures and are given access only to the open literature and commercial off-the-shelf technology.

more representative of a true tactical engagement, because the exact composition and type of countermeasures flown in an actual engagement are generally unknown. Details can be found in the classified version of this report.

Relative to the previous test program, MDA has substantially increased the scope of work being done in discrimination. MDA is pursuing a block approach that incrementally builds to a system-level discrimination architecture that incorporates a network of sensors. The idea is to observe the target suite throughout its trajectory using an array of ground- and space-based sensors and to combine individual observations to formulate a "discrimination solution." MDA is also investing resources to study the discrimination problem and, for example, is moving forward with flight test events focused on radar discrimination and large analysis programs.

MDA has plans to conduct four Radar Certification Flights through fiscal year 2006. These are non-intercept flight tests for comprehensively characterizing the discrimination capability of the X-band radar and to support the development of upgraded early warning radars. Furthermore, these tests are expected to have a "pop quiz" component to examine radar discrimination. MDA has not yet scheduled "pop quiz" testing in relation to kill vehicle's capability to perform target discrimination.

MDA initiated and continues to fund analysis programs for investigating promising technical concepts to improve its capabilities against enemy countermeasures. For example, one such program, Project Hercules, is focused on the development and testing of discrimination algorithms and draws on academic, government, and industry expertise. Details can be found in the classified version of this report.

Despite MDA's increased scope of work in the discrimination area, as described above, the agency's specific actions pertaining to integrated flight testing only partially address the August 2000 DOT&E recommendations. No intercept flight tests of the current test plan, which goes through IFT-26 (fiscal year 2007), are planned to address the challenge posed by an enemy's use of unsophisticated but more challenging countermeasures. Rather, agency officials told us that the technical challenges posed by such countermeasures are being analyzed and may be inserted into the flight test program at a later time.

DOT&E Recommendations on Programmatics

The remaining five recommendations from the August 2000 DOT&E report pertain to concerns on programmatic issues, namely, adequacy of spares in flight testing, and performance requirements. MDA has not provided for adequate target or interceptor backups (hot spares) during flight tests. MDA officials stated that additional target and interceptor spares can be costly, but they are considering the issue. Even if implemented, MDA's actions that address the recommendations on spares would not have a significant impact on the actual conduct of flight tests but would reduce schedule risk.

When DOT&E made its recommendations in August 2000, the GMD element was being developed according to operational requirements. However, MDA is now following a fundamentally new acquisition strategy—one that is capability-based with no formal operational requirements developed by the services. Hence, MDA has no plans to reexamine the reliability requirements. Nonetheless, the current test program is addressing certain performance issues raised by DOT&E. For example, the GMD program office is tracking the prime contractor's progress in meeting target discrimination goals.

Characterization of Initial Defensive Capability

Under the new acquisition strategy outlined by the Secretary of Defense in his January 2002 memorandum, the ballistic missile defense program has been refocused into a broad-based research and development effort managed by MDA. The new program aims at developing layered defenses to intercept missiles in all phases of flight and, if directed, to use developmental prototypes and test assets to provide an early operational capability. And, as stated above, system development is not subject to the formal operational requirements developed by the Services.

On December 16, 2002, the President directed DOD to begin fielding the first increment of the multi-element ballistic missile defense system in 2004. The Secretary of Defense stated the next day that "…it would be a very preliminary, modest capability." The initial defensive capability for defending the United States against long-range missiles would be based on the GMD element of the Test Bed and augmented with more interceptors and external sensors, as follows:

- **GMD Element as part of the BMDS.** The principal components of the GMD element for defensive operations include a total of up to 10 interceptors sited at Fort Greely (6) and Vandenberg Air Force Base (4); GMD fire control nodes at Fort Greely and Schriever Air Force Base for battle management and execution; an upgraded Cobra Dane radar at

Eareckson Air Station; and an upgraded early warning radar at Beale Air Force Base.

- **External Sensors.** Existing sensors external to the GMD element would also be available for defensive operations, including Defense Support Program satellites for early warning of missile launches, and three forward-deployed Aegis AN/SPY-1 radars on existing Navy destroyers for early midcourse tracking.

The above assets comprise the initial configuration, which is scheduled for fielding by the end of September 2004. The agency's near-term intention is to grow this capability by adding 10 interceptors at Fort Greely, a sea-based X-band radar, and an upgraded early warning radar at Fylingdales, England,[12] by the end of 2005.

Uncertainties of the Initial Defensive Capability

MDA is moving forward, as directed by the President, with the fielding of an initial defensive capability by the end of the 2004 fiscal year to protect the United States from long-range missiles. MDA cannot at this time formulate a credible assessment of system-level effectiveness, because critical components like the Cobra Dane radar and interceptor boosters have yet to be developed and tested in a flight test environment, and no initial defensive capability is available for a system-level demonstration and evaluation.

- **Cobra Dane Radar.** The capabilities of the Cobra Dane radar will not be demonstrated in flight testing before September 2004. It is an L-band phased array radar located at Eareckson Air Station in Shemya, Alaska, at the western end of the Aleutian chain. Its close proximity to Russia allows it to perform its primary mission of collecting data on intercontinental ballistic missile and submarine launched ballistic missile test launches to the Kamchatka impact area. Since the Cobra Dane radar is currently being used in a surveillance mode, it does not require real time communications and data processing capabilities. After planned software and hardware upgrades to be completed in fiscal year 2004, it will have the additional mission to perform real-time acquisition and tracking, functions critical for ballistic missile defense.
- **Interceptor Boosters.** In July 1998, the GMD prime contractor (Boeing) began developing a new three-stage booster for its ground-based interceptor from commercial off-the-shelf components. The contractor

[12] The upgrading of the Thule early warning radar located in Greenland will not be part of the Block 2004 Test Bed; it has been deferred to Block 2006.

encountered difficulty, and by the time the booster was flight tested in August 2001, it was already about 18 months behind schedule. Subsequently, to reduce risk, MDA altered its strategy for acquiring a new booster for the GMD interceptor. Development of the original booster was transferred to Lockheed Martin, and MDA authorized the GMD prime contractor to develop a second source for the booster by awarding a subcontract to Orbital Sciences Corporation. Both contractors are developing boosters for use in the September 2004 initial defensive capability. The first demonstration of an operational booster in an attempted intercept is scheduled for the third quarter of fiscal year 2004.

- **System-Level Testing.** A system-level demonstration of the initial defensive capability will not be conducted prior to September 2004. To date, integrated flight tests have demonstrated basic functionality of a representative ballistic missile defense system using surrogate and prototype components, and have shown success in intercepting a mock reentry vehicle in a developmental test environment. The first flight test consisting of components closest to the configuration of the September 2004 initial defensive capability is IFT-14, which is currently scheduled for the third quarter of fiscal year 2004. The test will incorporate Block 2004 prototypes of the interceptor booster and kill vehicle of the configuration intended for operational use beginning in September 2004. In addition, the first tactical build of the battle management software will be utilized in IFT-14. However, interceptors will not be launched out of Fort Greeley in IFT-14 and IFT-15 (the remaining integrated flight tests to be conducted before September 2004).

  In commenting on a draft of this report, MDA stated that while it cannot address all technical concerns for the initial fielding, it has added the following activities:

  - Enhanced producibility, quality, and reliability efforts.
  - Increased operational focus in the developmental program, e.g., military utility and effectiveness assessments.
  - Expanded command and control, battle management, and operator integration in BMDS testing to support fielding of initial defensive capabilities in 2004.

  MDA also stated that the results of these program decisions are intended to provide a comprehensive program that demonstrates operational effectiveness and military utility against credible threats in an operational environment.

Effectiveness of September 2004 and December 2005 Initial Defensive Capability

System effectiveness is characterized in terms of the following four performance metrics: (1) defended area, (2) launch area denied, (3) probability of engagement success, and (4) raid size breakpoint. Defended area is the portion of the United States protected against long-range missile attacks and, as a metric, is usually reported relative to a single threat country or region; launch area denied simply refers to the collection of threat countries from which the United States is protected. The probability of engagement success is the probability that all attacking warheads are destroyed, derived from the probabilities associated with missile defense functions like detection, discrimination, and hit-to-kill. Finally, raid size breakpoint is the maximum number of warheads the system can realistically defeat in a single engagement. This metric is highly dependent on interceptor inventory.

A detailed discussion of GMD's expected effectiveness is presented in the classified June 2003 version of this report.

Other Factors Affecting System Performance

A notable limitation of the effectiveness of the September 2004 initial defensive capability—and possibly the December 2005 capability—pertains to the inability of system radars to perform target discrimination. Neither the Cobra Dane radar nor the upgraded early warning radar at Beale is capable of performing rigorous discrimination, a function achievable only by the X-band radar. Rather, both radars will utilize common "target classification" software that enables them to classify objects as threatening or non-threatening. For example, debris would be classified as non-threatening, but objects like deployment buses and decoy replicas would be classified as threatening. Accordingly, the system would have to rely solely on the kill vehicle for a final target selection.

The assessment of kill vehicle discrimination is, therefore, critical for understanding the capability of the deployed system, a point made in the DOT&E report. Appropriately, the GMD prime contractor tracks the discrimination capability of the kill vehicle as a technical performance measure. The prime contractor's December 2002 assessment rated the kill vehicle discrimination performance as meeting expectations based on analysis and simulation.

Lastly, measures of system suitability like availability and vulnerability—which complement system effectiveness—are important for characterizing the initial defensive capability as a whole. MDA is aiming for full-time operations but faces risks in achieving this goal. Details on system

availability and vulnerability are provided in our June 2003 classified report.

Conclusions

Since DOT&E issued its August 2000 report, DOD has altered its approach to the acquisition of missile defense systems to one that follows a "capability-based" strategy. The new approach allows MDA to evolve and demonstrate additional improvements in missile defense systems before committing to procurement and operations. MDA's test program for all missile defense elements, such as GMD, was also reoriented to focus on the development and use of the BMDS Test Bed. Over time, the Test Bed should facilitate testing that address many of DOT&E's recommendations, especially those pertaining to flight test realism, complexity, and artificialities. However, most of the agency's actions with respect to DOT&E's ground testing recommendations, namely, those pertaining to comprehensive hardware-in-the-loop testing of the kill vehicle have been deferred. In addition, MDA is proceeding slowly with the flight testing against certain countermeasures, which DOT&E noted are simple for an enemy to implement. These unresolved concerns in the test program warrant attention by DOT&E and the test community in general. Given the importance of ground testing and discrimination testing for understanding system effectiveness, decision makers in the Congress and Office of the Secretary of Defense would benefit from having information on the agency's progress in these matters as they consider investments in developing the ballistic missile defense system. As an independent office that reviews DOD's weapon system testing and the office that made the recommendations discussed in this report, DOT&E would be in a good position to provide such information to decision makers.

Recommendations for Executive Action

As a means of providing decision makers with critical information when investments in missile defense are considered, we recommend that DOT&E report periodically, as it deems appropriate, on the status of MDA's actions taken or planned in response to the August 2000 recommendations. In its review, DOT&E should include information and recommendations, as warranted, on MDA's progress and planning (1) to improve hardware-in-the-loop testing of the kill vehicle, (2) to test kill vehicle components in nuclear environments, and (3) to test the GMD element's capability to defeat likely and simple near-term countermeasures during integrated flight tests. In the report, DOT&E can advise the Director, MDA, on how the test program could be modified to accommodate DOT&E's long-standing concerns.

Agency Comments and Our Evaluation

In commenting on a classified draft version of this report, DOD agreed with our recommendations. (See app. II for a reprinted version of DOD's comments.) However, DOD conveyed the following concerns:

- The GMD test program as described in this report is no longer current.
- It is difficult to reconcile the dated terms of reference of the original DOT&E recommendations with the current program strategy and structure.
- The inherent robustness of the envisioned layered BMD System relative to midcourse countermeasures is overlooked.

While the GMD test program has, indeed, been in a constant state of flux, thus complicating our analysis, our report presents the latest, approved test program information provided to us by MDA.

Despite alterations to the acquisition strategy and structure of the ballistic missile defense system and its constituent elements, like GMD, we believe most of the DOT&E recommendations are still relevant because the technical challenges and uncertainty with developing, testing, and fielding effective defensive capabilities, as identified in the August 2000 DOT&E report, remain significant. For example, the DOT&E report issued in February 2003, *FY02 Assessment of the Missile Defense Agency Ballistic Missile Defense System*, continued to highlight the need for a comprehensive hardware-in-the-loop capability to test the kill vehicle under the stress of real physical phenomena and to test the kill vehicle's discrimination capability. We do recognize that a number of recommendations for which no actions are currently planned, such as those recommendations dealing with flight testing during Initial Operational Test and Evaluation, are a direct result of MDA's new acquisition approach.

The department is correct in stating that we did not address the capability of the envisioned ballistic missile defense system as a whole in defeating midcourse countermeasures. However, we do note that a system-level discrimination architecture would use a network of ground- and space-based sensors to formulate a "discrimination solution." Also, given the early stages of development of the envisioned layered system, including boost-phase intercept, the value of this strategy has not been demonstrated.

Although the department agreed that DOT&E should report periodically on the status of MDA's actions to address the August 2000 DOT&E recommendations, it did not believe additional reporting is required to

track their resolution. The department pointed out that our recommendation grants DOT&E discretionary reporting authority where mandatory reporting already exists. We believe, however, the recommendation is worded appropriately. Existing statutory reporting requirements for DOT&E on the adequacy and sufficiency of the missile defense test program do not require that the August 2000 DOT&E recommendations be specifically addressed. We worded the recommendation to highlight the areas we believe DOT&E should address—hardware-in-the-loop testing of the kill vehicle, testing of kill vehicle components in nuclear environments, and testing the GMD element's capability to defeat likely and simple near-term countermeasures—and to give DOT&E the discretion to address our recommendation in the manner it deems appropriate. To present its assessment, DOT&E could use existing or new reporting vehicles.

Finally, department comments pertaining to MDA actions on ground testing are addressed in the body of this report.

As arranged with your staff, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from its issue date. At that time, we plan to provide copies of this report to interested congressional committees; the Secretary of Defense; and 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 staffs have any questions concerning this report, please contact me at (202) 512-4841. The major contributors to this report were Randy Zounes, Stan Lipscomb, Tana Davis, and Bill Graveline.

R E Levin

R. E. Levin
Director
Acquisition and Sourcing Management

Appendix I: Scope and Methodology

In examining the actions taken or planned by the MDA in response to the DOT&E recommendations, we analyzed pertinent test documents, studies, and reports. These include the (1) GMD Element Developmental Master Test Plan (March 2003); (2) GMD System Element Reviews; (3) MDA "immersion day" briefing; (4) MDA written responses to our questions about MDA actions in response to the DOT&E recommendations; (5) Secretary of Defense January 2002 Memorandum on Missile Defense Program Direction; and (6) Independent Review Team (Welch panel) Reports. In addition, MDA officials briefed us on GMD's program status and efforts to defeat enemy countermeasures. We also reviewed available documentation on the schedule and purpose of the Test Bed. These documents included studies on the enhanced test program restructure, fiscal year 2003 budget justifications, and the request for the contract proposal for the Block 2004 Test Bed.

To assess the effectiveness and limitations of the initial defensive capability, we relied on the following MDA documentation: (1) GMD System Element Review (January 2003); (2) BMDS Block 2004 Statement of Goals; and (3) National Security Presidential Directive (NSPD-23), the President's directive to begin fielding an initial capability. We also identified uncertainties—based on the level of testing achieved to date—of the potential capabilities of individual elements of the initial defensive capability, such as the radars and interceptor boosters, as well as radar capabilities to perform the discrimination function.

We conducted our work primarily at the MDA, located in Arlington, Virginia, and the GMD Joint Program Office, located in Arlington, Virginia, and Huntsville, Alabama.

We conducted our audit work for the June 2003 classified report, upon which this unclassified version is based, from October 2001 to March 2003 in accordance with generally accepted government auditing standards. However, reported dates of GMD flight test events given in this unclassified version have been updated with the latest (December 2003) GMD test schedules.

Appendix II: Comments from the Department of Defense

DEPARTMENT OF DEFENSE
MISSILE DEFENSE AGENCY
7100 DEFENSE PENTAGON
WASHINGTON, DC 20301–7100

JUN - 5 2003

Mr. R. E. Levin
Managing Director, Acquisition and Sourcing Management
U.S. General Accounting Office
441 G Street, NW
Washington, D.C. 20548

Dear Mr. Levin:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "MISSILE DEFENSE: Actions Being Taken to Address Testing Recommendations But Updated Assessment Is Needed," dated May 1, 2003 (GAO code 120098/GAO-03-279).

The Department partially concurs with the report but remains concerned that most of the test schedule and data are no longer current. Recommendations for factual corrections are provided in separate enclosure and are based on best information available to date. The Missile Defense Agency (MDA) continually reassesses its Ballistic Missile Defense System development and test program content and schedules, which impacts the Ground-Based Midcourse element. The three recommendations cited in the subject GAO report (Results in Brief) are prudent steps MDA is addressing as part of our evolutionary program planning. The Department agrees with the recommendation that "DOT&E should report periodically, as it seems appropriate, on the status of Missile Defense Agency's actions". However, this recommendation grants DOT&E discretionary reporting authority where mandatory reporting already exists. Additional reporting in order to track the resolution of DRR recommendations is not required.

The other difficulty with the report is reconciling the dated terms of reference of the original Dr. Coyle recommendations with the current BMD System program strategy and structure. For example, one recurring theme in missile defense program discussions is the recognized technical challenges and uncertainty with developing, testing, and fielding effective defensive capabilities. There is more than one path to retire the uncertainty characterized by the August 2000 DOT&E report. One option, as Dr. Coyle advocates, is to defer fielding any capability until much more progress is made to retire the majority of uncertainty, thereby delaying missile defense fielding several years, albeit with more confidence in the initial fielding. Or, as the evolutionary MDA approach emphasizes, we field many years sooner an initial capability of what is achievable while fully understanding and characterizing the known limitations (e.g., only modest ability to discriminate relatively simple decoys). Concurrently, we aggressively continue to develop and field additional improvements and, over time, achieve a robust defensive

system pacing the threat, responding to stakeholder needs, and capitalizing on program progress and successes. The Missile Defense Agency is implementing an innovative acquisition approach to manage more effectively this uncertainty (program risk), as acknowledged by the GAO report.

Another key point overlooked in the August 2000 DOT&E report, and now the subject GAO report, is the inherent robustness of the envisioned layered BMD System relative to midcourse countermeasures. The GAO report correctly identifies the challenges any of our midcourse defensive weapons and sensor systems would face in the presence of various decoys and countermeasures. But, the BMD program will evolve to include employment of layered sensors and Boost-phase intercept capabilities as an effective means to defeat midcourse countermeasures, sophisticated or otherwise, by destroying the adversaries' ballistic missile prior to the deployment of the enemy warhead and accompanying countermeasures. The value in this strategy must be factored in when making investment decisions for all available counter-countermeasure programs.

MDA's FY2004 President's Budget, describes program investments for improved hardware-in-the-loop facilities at the Arnold Engineering Development Center, Tennessee, to support sophisticated ground testing of major system components, to include ground-based kill vehicles, complete with synthetic scene generation capabilities. Similarly, we are planning to characterize the performance envelope of all of our system components relative to dealing with decoys and countermeasures, as well as a nuclear upset space environment. The timing and funding of these program test events, however, is subject to internal management trade-offs among the numerous priorities and fact-of-life pressures associated with the whole missile defense program portfolio. While we cannot address all technical concerns for the initial fielding, we have added:

- Enhanced producibility, quality, and reliability work in our R&D program efforts, backed by revised contractor incentive clauses;
- Increased operational focus in our developmental program including military utility and effectiveness assessments, live-fire lethality assessments, and linked measures of effectiveness for the BMD System and individual weapon and sensor components; and,
- Expanded command and control, battle management, and operator integration in the BMD System testing to support fielding of initial defensive capabilities in 2004.

The result of these program decisions provides a comprehensive program that demonstrates operational effectiveness and military utility against credible threats in an operational environment, and systematically retires both operational and technical risks

prior to initial operations. As we learn more about our capabilities and limitations in our development and testing, our program management processes are structured to incorporate practicable adjustments.

My point of contact for this report is Mr. Luis A. Villalobos, (703) 697-7465, luis.villalobos@mda.osd.mil.

The Department appreciates the opportunity to comment on the draft report.

Sincerely,

ROBERT SNYDER
Executive Director

Enclosures:
As stated

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