BALLISTIC MISSILE DEFENSE SYSTEM (BMDS)

BACKGROUND

In January 2002, the Secretary of Defense created the Missile Defense Agency (MDA) and consolidated the ballistic missile defense programs under the new agency. The rationale behind this decision was the creation of a comprehensive, integrated Ballistic Missile Defense System (BMDS) that provides a layered defense capable of countering threat missiles in all phases of flight. Former missile defense acquisition programs are now referred to as BMDS elements. Leading up to this restructure, DOT&E oversight of program activity was very limited. However, involvement in the planning, observation, and evaluation of documentation and test events improved significantly throughout 2002. With the exception of PAC-3, which is in the process of being transitioned to the Army, all of the BMDS elements are in a Research and Development Test and Evaluation phase.

MDA has adopted a capability-based acquisition strategy with 2-year development blocks. Technical goals and objectives for each block are based on promising new technologies, progress in the development of BMDS elements, and estimates of current and future threat capabilities. These blocks provide manageable development increments and opportunities to fielding capabilities as they mature. Critical assessments of military utility and operational effectiveness, suitability, and survivability will accompany each block decision. While developmental goals will be based on broad classes of missions and threat characteristics, operational assessments of a block's demonstrated capabilities will be based on more specific missions and threats.

The Secretary established a Department goal to develop a layered BMDS capable of defending the United States, deployed forces, allies, and friends using prototypes and test assets to provide early capability, if necessary. DOT&E is responsible for providing advice to the Director, MDA on his goals and objectives for the BMDS. Due to the restructuring, detailed goals and objectives were not available in FY02, but the MDA provided information on their evolving plans for the test bed architecture, element research plans, and management strategy. MDA very recently provided their proposed Technical Goals and Objectives for review and comment. These goals and objectives outline the components and layered systems that are planned for the Block 2004 test bed. These plans also extend to the Block 2006 test bed configuration. Given their preliminary nature and the time available to review these plans prior to this report, the capability that each element may contribute to the test bed will be discussed separately, recognizing the intent to demonstrate an integrated layered defense in the future. The test bed approach answers some aspects of long standing criticism regarding a lack of flight test and system integration realism. Currently the planned test bed infrastructure for Block 2004 includes hardware and software components that are in active development. As the test bed matures and capabilities are demonstrated, an inherent defensive capability will develop. However, it will be very difficult to estimate operational availability or performance in real engagement conditions. This is a test bed, first and foremost.

MDA has established corporate activities for characterizing threat capabilities, building targets and countermeasures, and studying system lethality. These initiatives, as well as the major BMDS elements, are discussed in the following unclassified summary. More detailed discussions are available in a classified report to Congress.

THREAT BALLISTIC MISSILES

MDA is preparing an Adversary Capabilities Document that describes the threat missiles typically identified in a System Threat Assessment Report. The Adversary Capabilities Document will emphasize performance characteristics that describe threat capabilities, accounting for uncertainty in intelligence data and threat evolution. This will facilitate the evaluation of system performance against a range of threat characteristics relevant to the intended defeat mechanisms. For example, missile body construction, rocket motor internals, and fuel type are threat characteristics that will demonstrate BMDS effectiveness when employing a laser weapon, while the effectiveness of a direct hit interceptor will depend much more heavily on threat trajectory, decoys, or terminal maneuvers.

TARGETS

The target development program is designing targets that can emulate the physical and flight characteristics of a broad range of threats. Since detailed targets which are representative of an actual threat are extremely expensive and prone to changing intelligence estimates, a robust, versatile set of targets is needed. Limitations on test ranges, practical limits on program budgets, uncertainties in the threat, and the enormous variety of conditions under which a system may be employed, require that hardware-in-the-loop facilities, models, and simulations be used to extend understanding of system performance against various threats. Test targets that can be flown in a variety of modes are an important aspect of sensitivity assessments that validate the models and simulations used to predict missile system performance.

LETHALITY

Lethality has long been defined at intercept. Kill criteria have been based on destroying the lethal payload, dismembering the warhead or rendering the payload inert, or damaging the aeroshell sufficiently to prevent the threat missile from hitting its intended target. When the intended target of the threat missile is an area populated with allied soldiers or civilians, the suitability of these criteria is questionable, since they do not address residual effects on the ground due to an intercept. The technical challenges to estimating these effects are substantial, and are proving very difficult. The MDA lethality program is pursuing research activities to characterize impact damage, evaluate agent response to impact and aerodynamic forces, and examine the transport mechanisms that deliver residual agents to the ground. Over the years, DOT&E has encouraged research to better understand ground effects and will continue to follow developments to assure that kill assessment methodology is updated and consistently integrated into an operational context.

ASSESSMENTS OF BMDS ELEMENTS

The BMDS elements have made progress this year in one or more of four areas: flight tests, system ground tests, component ground tests, or system definition. The following sections briefly discuss the major BMDS elements. More detail is included in our classified report to Congress.

GROUND-BASED MIDCOURSE DEFENSE

The Ground-Based Midcourse Defense (GMD) element mission is to defend the United States against a limited strike of Intercontinental Ballistic Missiles (ICBMs) from rogue nations, and unauthorized or accidental launches from nations with existing nuclear weapons. The GMD element is an integrated collection of components that perform dedicated functions during an ICBM engagement. As planned, the GMD element includes the following subsystems:

- GMD Battle Management, Command and Control and communications network
- In-Flight Interceptor Communications System
- Long-range sensors, including Upgraded Early Warning Radars and a sea-based X-Band Radar
- Ground Based Interceptors emplacements, consisting of a silo-based ICBM-class booster motor stack and the Exoatmospheric Kill Vehicle. The President's announced plan for the 2004 Test Bed plan places six Ground Based Interceptors at Fort Greely, Alaska, and four at Vandenberg Air Force Base, California. In 2005, plans are to place ten more at Fort Greely.

GMD plans to interface with other BMDS elements and existing systems through external system interfaces. Through FY06, these plans include GMD interfacing with the Cobra Dane radar, SPY-1B radars on Aegis ships, and Satellite-based sensors in the existing Defense Support Program.

In FY02, the GMD program continued to demonstrate the technical feasibility of intercepting a "bullet with a bullet" against simple target complexes. However, due to the stage of development and the following testing limitations, the GMD element has yet to demonstrate significant operational capability. The GMD test program in FY02 has suffered from the lack of production representative test articles and test infrastructure limitations. It is noteworthy, however, that these limitations are not the result of conscious decisions to minimize the test program, but result from an effort to gain early insight into system design at a reasonable pace and cost. The GMD program is taking a slower, more deliberate approach to testing to reduce both testing and program risk. This approach essentially responds to the "rush to failure" criticism received from the Welch Panel. It is also a sound engineering approach for maturing both the system design and test infrastructure. GMD is addressing these limitations as the 2004 GMD Test Bed is defined. Highlighted limitations are described in Table I below.

Table I. Major GMD Test Limitations and MDA Mitigation Plans

Limitation	Comments	MDA Mitigation Plan
Lack of a deployable boost vehicle	A deployable boost vehicle has yet to be developed. Integrated flight tests have used boost vehicles with lower burnout velocity and agility. Intercepts have been achieved in a small region of the threat engagement space.	Two boost vehicles are under development. Initial flight testing of both vehicles is scheduled for FY03.
Lack of a realistically placed midcourse sensor	The GMD test radar is collocated at the interceptor launch site. The FPQ-14 radar, a non-deployable asset, which tracks a transmitter located on the test target, currently accomplishes the midcourse tracking and discrimination functions.	Development of a mobile, sea-based radar is planned. GMD has scheduled incorporation of this radar into the GMD Test Bed in the post-2005 time frame.
Fixed intercept point	All of the flight tests have similar flyout and engagement parameters. This limitation includes range constraints and a requirement not to create space debris.	The 2004 Test Bed will expand the range of flyout and engagement conditions. Space debris creation remains a problem.[a]

[a] This constraint continues to force an unrealistic engagement at relatively low altitudes and with both the target and interceptor velocities directed downward.

The flight test agenda for FY02 was intended to further validate the "hit-to-kill" concept for ICBM defense. To provide more confidence in the concept, MDA planned Integrated Flight Test (IFT)-7 to be identical to the previously successful IFT-6. Also, IFT-8 was nearly identical to IFT-7, with the exception of additional balloons in the target complex. These balloons were not intended to be representative of actual countermeasures, but to increase the number of objects to be tracked, without over-stressing the ground sensor or kill vehicle discrimination capabilities.

In early FY03, GMD executed IFT-9 and IFT-10. IFT-9 had the same engagement parameters as IFT-8 with a slightly different, but still simple, target complex. Additionally, an Aegis SPY-1 radar participated as an associated operation to gather data for more active roles in future flight tests. IFT-9 successfully intercepted the reentry vehicle. In December 2002, GMD attempted a night intercept on IFT-10. The Exoatmospheric Kill Vehicle failed to separate from the surrogate test booster and could not be guided to the target. Failure analysis for this event is ongoing. The Airborne Laser prototype aircraft participated and successfully tracked the target with its passive infrared sensor.

The Program Office has suspended intercept flight-testing until the two developmental tactical boosters have been successfully tested during IFT-13a and IFT-13b. Intercept flight tests, IFT-11 and IFT-12, have been eliminated from the schedule. IFT-14 will be the next intercept attempt and will accommodate IFT-10 and IFT-11 test objectives. This decision is reasonable given the increased risk of surrogate booster failure, the resources that would have to be diverted from tactical booster development to fix the problems, and the limited amount of additional information would be gained in IFT-10 and IFT-11 over that available from previous flight tests.

MDA must successfully complete planned developments to build and deploy the 2004 Test Bed so it is available to support integrated system level testing that will verify the adequacy of the GMD system design and demonstrate its limited operational capability in the case it is needed for emergency defense. Three critical developments include: a deployable boost vehicle, demonstrated and integrated with the kill vehicle; a midcourse sensor to provide adequate real-time track and classification capabilities to support an engagement; and kill vehicle discrimination and homing at higher closing velocities and against targets with signatures, countermeasures and flight dynamics more closely matching the threat. Threat likeness should consider infrared and radar signatures, tumbling targets, and off-nominal target complex deployments. Test design should reflect the operators' imperfect knowledge of the characteristics of the threat. In addition, testing must demonstrate all necessary communications and interfaces with external systems. Testing should go beyond the typical proof-of-concept demonstrations in order to provide a higher confidence in estimates of operational capability.

The planned GMD 2004 Test Bed program is expected to accomplish some of these objectives. Key exceptions are demonstrating kill vehicle performance in the absence of detailed foreknowledge of target characteristics and against tumbling or off-nominally deployed targets. Given the uncertainty of the threat, it is unclear that the target signatures will be consistent with the threat when fielded.

AEGIS BALLISTIC MISSILE DEFENSE

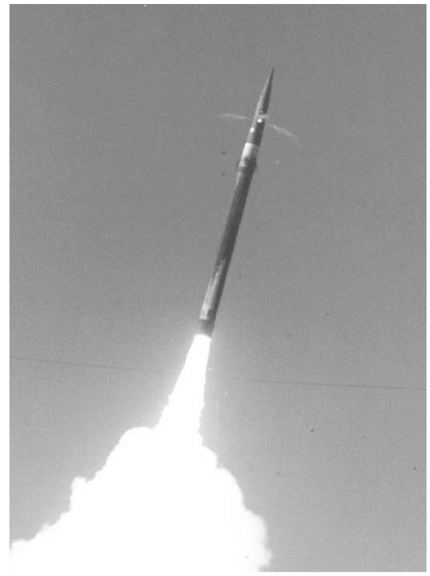
The Aegis Ballistic Missile Defense (Aegis BMD) element is intended to provide U.S. Navy surface combatants with the capability to defeat short, medium, and long-range ballistic missiles during exoatmospheric flight. Ultimately, the Aegis BMD system is intended to act in concert with other boost, midcourse, and terminal defensive elements of the BMDS.

The Aegis BMD test strategy through FY02 has been commensurate with the early maturity level of the system. Flight test engagement scenarios have been simplistic and limited to establishing the hit-to-kill proof-of-concept, and flight qualifying non-legacy hardware and software components of the Aegis BMD system. The ground test program on the solid-fuel divert attitude control system has demonstrated good performance using a simpler, more producible monolithic design. These ground test results support the planned transition to flight-testing with a fully capable divert system. Lethality ground testing to date has established an important collection of data for assessing the lethality of an intercept event.

All three intercept shots (Flight Missions-2, 3, and 4) in 2002 were successful, with Flight Mission 4 demonstrating an ascent phase intercept. The flight test engagement geometries, scenarios, and timelines were non-stressing. These missions employed a simplified divert system design that has demonstrated sufficient agility to intercept at the target mid-body. A more sophisticated divert system, capable of multiple divert pulses, is under development and must be integrated into the system before engagement of the target warhead section is possible. Prior to Flight Mission-4, test targets were not threat-representative in trajectory and pointing attitude, employing a lofted trajectory and a constant target aspect angle that increased the target radar cross section as viewed from the ship. For Flight Mission-4, the target was representative in both trajectory and signature. Flight tests have used unitary targets, with no intercept attempts against more stressing separating targets. Flight tests against separating threats, or threats that employ countermeasures, are required to fully assess the discrimination and designation capability of Aegis BMD. These test limitations will be addressed as the Aegis BMD program matures and the test program becomes more challenging.

Since these firings have been from functional, fully manned, operational ships, this system could be employed in an emergency with limited expectation of success. There are significant capabilities yet to be demonstrated before the engagement conditions can be considered operationally realistic.

THEATER HIGH ALTITUDE AREA DEFENSE



The Theater High Altitude Area Defense (THAAD) is a mobile ground-based missile defense element designed to protect forward-deployed military forces, population centers, and civilian assets from Short and Intermediate Range Ballistic Missile attacks. THAAD is intended to intercept incoming ballistic missiles using kinetic energy "hit-to-kill" technology. The THAAD system is intended to be capable of intercepting missiles at either high endoatmospheric or exoatmospheric altitudes. THAAD plans to provide an upper-tier missile layer of defense complementing the lower-tier PATRIOT Advanced Capability-3 (PAC-3).

The THAAD test program continued to show progress during FY02, with several successful component-level contractor tests. Additionally, THAAD demonstrated limited interoperability with other BMDS systems (PATRIOT and Aegis) in hardware-in-the-loop tests.

Funding shortfalls have reduced the number of spare flight missiles to one and have caused the flight test program to be extended about nine months. An earlier schedule showed the last flight test in 2QFY08; it is now scheduled for 4QFY08.

Element restructuring has also shifted some essential ground testing events to occur later in the program, relative to flight testing. The THAAD element's first flight test intercept attempt against a threat-like missile is planned for 1QFY06. Missile safety testing, system level mobility, logistics, environments, reliability, and maintainability are all tested later in the program. The prioritization of flight testing is intended to reduce the risk of finding significant system integration problems late in the test program. This is a sound approach, but means that significant ground testing will have to be performed if a decision is made to deploy capability early.

At this time, the THAAD element has no operational capability because there is no deployable hardware.

PATRIOT ADVANCED CAPABILITY-3

The PATRIOT air defense system uses guided missiles to engage and destroy air-breathing threats (ABTs) and tactical ballistic missiles (TBMs). PAC-3 Configuration-3 is the latest version. The PATRIOT system is designed to defend against multiple hostile TBMs and ABTs in electronic countermeasures and clutter environments. The ABTs include fixed-wing and rotary-wing aircraft, cruise missiles, tactical air-to-surface missiles, anti-radiation missiles, and unmanned aerial vehicles.

The PAC-3 Configuration-3 system underwent Initial Operational Test and Evaluation (IOT&E) between February and September 2002. IOT&E, when combined with the developmental test and lethality test programs that were completed in 2001, was adequate to assess the potential operational effectiveness, suitability, survivability, and lethality of the PAC-3 system against a set of existing and postulated threats.

The PAC-3 Follow-On Test Program (FOTP) currently consists of one flight test in FY03, five in FY04, twelve in FY05, and five in FY06 and beyond. The flight tests in FY05 and beyond are not yet funded. The FY03 flight test is scheduled for May 2003 and will consist of two PAC-3 missiles ripple-fired at a TBM target flying the same trajectory as the Operational Test/Developmental Test (OT/DT)-4a target. DT/OT-11 is scheduled for February 2004. It is a PAC-3 ripple-fire (shoot-shoot) engagement against a TBM target and a PAC-3 shoot-look-shoot engagement against a cruise missile target flying the same trajectory as the Operational Test-3b target. DT/OT-12 is scheduled for April 2004 and will consist of PAC-3 ripple-fire engagements against two TBM targets. The first interceptor fired against each target in DT/OT-11 and DT/OT-12 will be built with the cost-reduction initiative hardware changes that are intended to reduce the cost of the PAC-3 missile without reducing capability. The other three FOTP flight tests in FY04 will be ripple-fire engagements against short-range TBMs performing in-plane, out-of-plane, and range-extension maneuvers.

PAC-3 system capability is discussed in detail in the classified beyond low-rate initial production (BLRIP) report dated October 2002. The BLRIP report supported the Defense Acquisition Board's review of the program in late 2002 and its recommendation to transfer the PAC-3 program to the Army for all future development and procurement. While the Acquisition Decision Memorandum has not yet been approved, it is expected that the Army's plan will be approved to purchase 208 additional missiles in FY03- 04 to meet immediate inventory needs. The program office has proposed a robust follow-on test program, details of which are in the final stages of definition. It is essential that the transition to the Army include the funding resources needed to properly execute the follow-on test program.

MEDIUM EXTENDED AIR DEFENSE SYSTEM

The Medium Extended Air Defense System (MEADS) is intended to be a highly mobile air defense system for protection of maneuver forces and fixed assets. The system should provide area and point defense capabilities against multiple, simultaneous, 360-degree attacks by ballistic missiles, large caliber rockets, fixed-wing and rotary-wing aircraft, unmanned aerial vehicles, cruise missiles, tactical air-to-surface missiles, and anti-radiation missiles. It should be strategically deployable by C-130 roll-on/roll-off and tactically mobile to keep up with maneuver forces. MEADS has not yet entered the Design and Development phase; testing to date has been limited. MEADS is in the early prototyping stages and has demonstrated no operational capability to date.

The MEADS is an international program being developed to meet the technical requirements agreed to by the MEADS partners: the United States, Germany, and Italy. In July 1996, NATO formed the NATO MEADS Management Agency (NAMEADSMA) to lead program activity. The United States, Germany, and Italy have staffed the agency.

The proposed program management structure includes both U.S. and international arrangements. U.S. oversight is accomplished through the Integrated Product Team process. The Army's MEADS National Product Office oversees U.S. requirements development and serves as the single point of contact for U.S. support to NAMEADSMA. International oversight is accomplished through the National Armaments Directors and a MEADS Steering Committee. The Army Program Executive Officer for Air and Missile Defense represents the U.S. on the Steering Committee. Leadership positions of NAMEADSMA will rotate among the nations.

Significant differences between the threats, operational environments, operational concepts, and technologies employed for MEADS and PAC-3 dictate a robust developmental and operational test that builds on the PAC-3 testing efforts. DOT&E is engaged in on-going testing program negotiations.

AIRBORNE LASER

The Airborne Laser (ABL) is intended to shoot down enemy ballistic missiles during their boost phase. The ABL engagement concept is to place laser energy on the threat missile booster motor casing, rupturing or damaging it sufficiently to cause the missile to lose thrust or flight control and fall short of its intended target. The ABL engagement of ballistic missiles in the boost phase is intended to negate the missile before decoys, warheads, or submunitions are deployed.

Currently three different Block configurations are planned: Blocks 2004, 2006, and 2008. Blocks 2004 and 2008 are on Boeing 747 transport aircraft modified to accommodate ABL subsystems. Block 2006 consists of hardware and software updates and continued testing of the 2004 weapon system Block 2008 will also include the "Iron Bird," a ground test facility constructed inside the hull of a 747. The scope of the Iron Bird ground test facility is still under discussion, but it is expected to develop from the System Integration Lab. The System Integration Lab is a facility at Edwards Air Force Base where the Block 2004 laser software and hardware will be integrated and tested prior to being integrated into the Block 2004 aircraft. Block 2006 will include the production of deployment specific sub-systems, including a deployable chemical farm. During Block 2006, there will also be software and hardware enhancements to the ABL interoperability.

During FY02, the detection and tracking capabilities of the passive infrared sub-system were tested. It successfully tracked F-16s during multiple flight tests. After verifying surveillance functionality with the F-16s, a Lance missile was successfully tracked. Also, the GMD IFT-10 target was acquired and tracked by the passive infrared sensor, and tracking data was collected for analysis. A determination of whether the track quality was sufficient for Battle Management is expected in 2QFY03. Vibration in the Active Ranging System pod during the first flight and subsequent test flights of the block 2004 aircraft prompted a re-design study of that structural component.

The ABL Block 2004 test program has significantly improved in the last year due to extension of the testing schedule, resulting in a more realistic plan. The primary goal for Block 2004 is to demonstrate and ability to defeat a threat ballistic missile using an airborne laser. Operational capabilities testing will not occur before the system demonstration at the end of CY04. Due to the developmental nature of the Block 2004, there will be limited information on operational capability until after the system demonstration. There is currently no ABL emergency capability apart from some passive detection capabilities.