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

The Honorable Duncan Hunter
Chairman
Committee on Armed Services
U.S. House of Representatives
Washington, DC 20515

APR 20 2006

Dear Mr. Chairman:

The House Appropriations Committee Report (H.Rept. 109-119) to accompany H.R. 2863, the Department of Defense Appropriations Act, 2006, requests that the Secretary of Defense conduct a joint study with the Government Accountability Office (GAO) to review the early engagement of ballistic missiles to include boost and ascent phase intercepts. The committee directed that the enclosed report be provided no later than 90 days after the enactment of Department of Defense Appropriations Act, 2006, and specifically include, but not limited to, the following: "(1) An assessment of the operational capabilities of systems against ballistic missiles launched from North Korea or a location in the Middle East against the continental United States, Alaska, or Hawaii; (2) An assessment of the quantity of operational assets required for deployment periods of seven days, thirty days, ninety days and one year; (3) Basing options; and (4) An assessment of life-cycle costs to include research and development efforts, procurement, deployment, operating and infrastructure costs."

The National Defense Authorization Act, Fiscal Year 2006, (Public Law 109-163), section 231, directs that the Secretary of Defense "conduct an assessment of the United States missile defense programs that are designed to provide capability against threat ballistic missiles in the boost/ascent phase of flight. The purpose of the assessment shall be to compare and contrast: (1) capabilities of those (missile defense) programs (if operational) to defeat, while in the boost/ascent phase of flight, ballistic missiles launched from North Korea or a location in the Middle East against the continental United States, Alaska, or Hawaii; and (2) asset requirements and costs for those programs to become operational with the capabilities referred to in paragraph (1)."

~~UNCLASSIFIED WHEN SEPARATED FROM CLASSIFIED ATTACHMENTS~~

The Missile Defense Agency prepared the report on behalf of the Secretary of Defense to address both the request in the Appropriations Committee Report and the requirements of section 231 of the 2006 National Defense Authorization Act. A similar letter is being sent to the Chairmen and Ranking Members of the other congressional defense oversight committees.

Sincerely,

HENRY A. OBERING III
Lieutenant General, USAF
Director

Enclosure:
As stated

cc:
Honorable Ike Skelton
Ranking Member

SECRET

**DEPARTMENT OF DEFENSE**
**MISSILE DEFENSE AGENCY**
**7100 DEFENSE PENTAGON**
**WASHINGTON, DC 20301-7100**

APR 20 2006

The Honorable John W. Warner
Chairman
Committee on Armed Services
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

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Sincerely,

HENRY A. OBERING III
Lieutenant General, USAF
Director

Enclosure:
As stated

cc:
The Honorable Carl Levin
Ranking Member

~~SECRET~~

DEPARTMENT OF DEFENSE

MISSILE DEFENSE AGENCY
7100 DEFENSE PENTAGON
WASHINGTON, DC 20301-7100

The Honorable Ted Stevens
Chairman
Subcommittee on Defense
Committee on Appropriations
United States Senate
Washington, DC 20510

APR 20 2006

Dear Mr. Chairman:

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Sincerely,

HENRY A. OBERING III
Lieutenant General, USAF
Director

Enclosure:
As stated

cc:
The Honorable Daniel K. Inouye
Ranking Member

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

APR 20 2006

The Honorable C.W. "Bill" Young
Chairman
Subcommittee on Defense
Committee on Appropriations
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

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Sincerely,

HENRY A. OBERING III
Lieutenant General, USAF
Director

Enclosure:
As stated

cc:
The Honorable John P. Murtha
Ranking Member

# REPORT TO CONGRESS (U)

## Assessment of

## Boost and Ascent Phase Missile Defense Capabilities

## 30 March 2006

## Missile Defense Agency

Derived From: BMDS SCG dtd 26 April 2004
Declassify on OADR: 26 April 2029

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# REPORT TO CONGRESS (U)

*Submitted in Response to the*
*Department of Defense Appropriations Act for Fiscal Year 2006*
*And*
*National Defense Authorization Act for Fiscal Year 2006 (U)*

## Report on Boost and Ascent Phase Missile Defense Capabilities (U)

## I. Executive Summary (U)

### Boost and Ascent Phase (U)

(U) The mission of the Missile Defense Agency (MDA) is to develop and field a joint, integrated, multilayered Ballistic Missile Defense System (BMDS) to defend the United States, its deployed forces, and our friends and allies against ballistic missiles of all ranges and in all phases of flight. Boost phase intercept is a vital segment of that multilayered defense. Intercepts in the boost phase offer distinct advantages over intercepts of reentry vehicles in the midcourse and terminal phases of flight and are a potentially highly effective way of denying an adversary the opportunity to deploy countermeasures against midcourse defense elements.

(b)(1) [redacted]

(U) Therefore, the Ballistic Missile Defense System includes a combination of weapon capabilities that provide multiple ways and opportunities to engage and defeat ballistic missiles in all phases of flight. The synergies achieved through the combination of boost, ascent, midcourse, and terminal intercept capabilities are critical to the realization of a robust and cost-effective Ballistic Missile Defense System.

(U) The characteristics, projected capabilities, and estimated costs of, and operational considerations for, the Ballistic Missile Defense System elements that are designed to have capabilities to intercept ballistic missiles during their boost and ascent phases of flight are the subject of this report.

(U) The Missile Defense Agency prepared this report on behalf of the Secretary of Defense. During the preparation of the portion of this report responding to the House Appropriations Committee Report (House Report, 109-119, page 294), the GAO declined to participate in the joint study, indicating that it is an independent review Agency. Letters were prepared and forwarded to the Chairmen and Ranking Members of the congressional defense oversight committees to advise them of this change. Copies of those letters are included with this report at Appendix B.

**The Charge (U)**

(U) On behalf of the Secretary of Defense, the Missile Defense Agency formed a team to assess what is known today about the expected capabilities and costs for operational boost and ascent phase missile defense systems. This report responds to the requests in House Appropriations Committee report (House Report, 109-119, page 294) and section 231 of the National Defense Authorization Act, Fiscal Year 2006, (Public Law 109-163).

(U) In House Report 109-119, the Congress requests a study of the early engagement of ballistic missiles including boost and ascent phase intercepts, including but not limited to the following elements in its comparison:

1) *An assessment of the operational capabilities of systems against ballistic missiles launched from North Korea or a location in the Middle East against the continental United States, Alaska or Hawaii;*
2) *An assessment of the quantity of operational assets required for deployment periods of seven days, thirty days, ninety days and one year;*
3) *Basing options; and*
4) *An assessment of the life cycle costs to include research and development efforts, procurement, deployment, operating and infrastructure costs.*

(U) In section 231, the Congress directed that:

a) *The Secretary of Defense shall conduct an assessment of the United States Missile Defense programs that are designed to provide capability against threat ballistic missiles in the boost/ascent phases of flight.*
b) *The purpose of this assessment shall be to compare and to contrast:*
    *1) capabilities of those programs (if operational) to defeat, while in the boost/ascent phase of flight, ballistic missiles launched from North Korea or a location in the Middle East against the United States, Alaska or Hawaii and,*
    *2) asset requirements and costs for those programs to become operational with the capabilities referred to in paragraph 1.*

(U) This report is intended to satisfy both requests.

**<u>The Focus and Approach (U)</u>**

(U) In accordance with the study direction, the study team considered ballistic missiles launched from locations in North Korea or in the Middle East against the continental United States, Alaska and Hawaii. Iran was used as the Middle East focus. We began by identifying those Ballistic Missile Defense System elements that would be included in this report. They include currently programmed elements that will add initial boost and ascent phase operational capability to the Ballistic Missile Defense System in the 2015-2020 timeframe.

(U) We then identified where, in principle, those weapons could conduct engagements during the boost and ascent phases of flight and then determined the number of weapon stations needed to defend the entire continental United States, Alaska and Hawaii against launch of representative, first-generation ICBMs from the two missile launch regions. For those cases where an element covered less than 100 percent of the United States areas to be defended, we show how much the system can contribute to missile defense in the boost and ascent phase layers. We analyzed a range of potential adversary missile characteristics to avoid presenting an overly optimistic or pessimistic performance assessment and to identify a range of possible outcomes to give the reader insight into the impact of various ballistic missile parameters that need to be considered when assessing potential operational employment of these elements.

(U) The Airborne Laser (ABL), Kinetic Energy Interceptor (KEI), and Aegis Ballistic Missile Defense (Aegis BMD) with the Standard Missile-3 (SM-3) Block IIA interceptor are the elements of the Ballistic Missile Defense System considered in this report. All are expected to have initial operational capabilities in the 2015 to 2020 timeframe. The estimated operational capability of the second Airborne Laser aircraft, designated Tail-2 is used as the basis for Airborne Laser capabilities in this report. This configuration will initially demonstrate operational capability in the Block 2016 testbed with a fully tested operational capability in Block 2018. The Kinetic Energy Interceptor will initially demonstrate land-mobile operational capability in the Block 2012 testbed and sea-mobile operational capability in the Block 2014 testbed, with fully tested operational capabilities in Block 2014 and Block 2016 respectively. The Aegis Ballistic Missile Defense with the SM-3 Block IIA interceptor will initially demonstrate operational capability in the Block 2012 testbed with fully tested operational capability in Block 2014.

(U) We specifically address the individual capabilities of these elements to defend the United States from ICBM attack from North Korea and Iran with intercept in the boost and ascent phases. Additional element defense capabilities against shorter range ballistic missiles, for different defended regions, or in different engagement phases (midcourse and terminal) are not specifically addressed in this report. Other defense elements are considered and discussed only as needed to provide an appropriate Ballistic Missile Defense System context.

(U) We address all of the requested areas, however, the Airborne Laser, Kinetic Energy Interceptor, and the Aegis Ballistic Missile Defense SM-3 Block IIA interceptor are still in the early phases of development and demonstration and their operational concepts are not mature or fully vetted within the user communities. As a result, limited analysis and data exists at this time to be able to provide a full assessment of the operational assets required for deployment periods of seven days, thirty days, ninety days, and one year for each element. Where limited analysis is available, we have attempted to provide the reader with that information to provide a sense of the operational implications of each element. Additionally, there is substantial uncertainty in estimating full life cycle costs for these elements at this time. We are providing development cost estimates and initial estimates for fielding and operations and support costs consistent with where these programs are in their development cycle. As these elements reach their knowledge-based decision points, the technical designs mature, potential fielding quantities are determined, and concepts of employment and operation are defined and vetted with the user communities, we will have additional, more definitive information in these areas.

**<u>Boost and Ascent Phase Findings (U)</u>**

- (U) Boost phase intercept capability is a vital segment of the integrated multilayered Ballistic Missile Defense System. An effective boost layer negates midcourse countermeasures and thins multiple ballistic missile launches giving subsequent layers, and the Ballistic Missile Defense System as a whole, greater opportunity to completely negate the threat.
    - Each of the elements described in this report can either operate independently from the other layers of the Ballistic Missile Defense System or can contribute to the overall Ballistic Missile Defense System effectiveness. The operational comparisons are for stand-alone only.
- (U) Effective defense against ballistic missiles during the boost and ascent phases requires forward operating locations for defensive assets in close proximity to the adversary in order to reach these ballistic missiles while still in the boost or ascent phases. Access to this early engagement space requires mobile defenses that can react and engage ballistic missiles within very short time windows.

(b)(1)

[redacted]

(b)(1)

[redacted]

[redacted]

(b)(1)

[redacted]

- (U) Airborne Laser requires at least three aircraft for a near-continuous single combat air patrol station. More may be required depending on the length of deployment, capabilities of the aircraft available, and whether or not the Combatant Commander needs near-continuous or continuous coverage. The specific quantity of operational assets required for deployment periods of seven days, thirty days, ninety days and one year have not yet been determined.

- (U) The land-mobile Kinetic Energy Interceptor element is designed to be sustainable over extended periods of time; a single asset can maintain continuous coverage while deployed. Sea-mobile Kinetic Energy Interceptor asset requirements would vary based on the platform that is used; several surface ship and submarine platform alternatives are currently under study by the Navy and the Missile Defense Agency. For long periods of at least a year, three submarines or four surface ships would be required to maintain a single station. It is expected that fewer assets would be required for shorter durations (seven days, thirty days, and ninety days); however, the appropriate ratio has not yet been determined.

- (U) The number of SM-3 Block IIA equipped Aegis ships required to maintain continuous ascent phase intercept coverage would be similar to the number required for sea-mobile Kinetic Energy Interceptor. Aegis ship requirements would also be comparable to the number of assets required to fill the Ballistic

Missile Defense patrol area in support of the long range surveillance and track mission currently being performed by the Navy. The specific quantity of operational assets required for deployment periods of seven days, thirty days, ninety days and one year have not yet been determined.

- (U) The pace and direction of adversary ballistic missile capability development is uncertain and the possible incorporation of countermeasures could potentially reduce the effectiveness of one or more of these boost/ascent phase intercept elements. Therefore, the parallel development and demonstration of the three Ballistic Missile Defense System boost/ascent intercept capabilities provides a prudent range of technical and operational alternatives to defeat evolving adversary capabilities and a means to address potential countermeasures in the boost/ascent intercept phases as well as across subsequent intercept phases.

(b)(1),(b)(5)

[redacted]

(b)(5) [redacted]

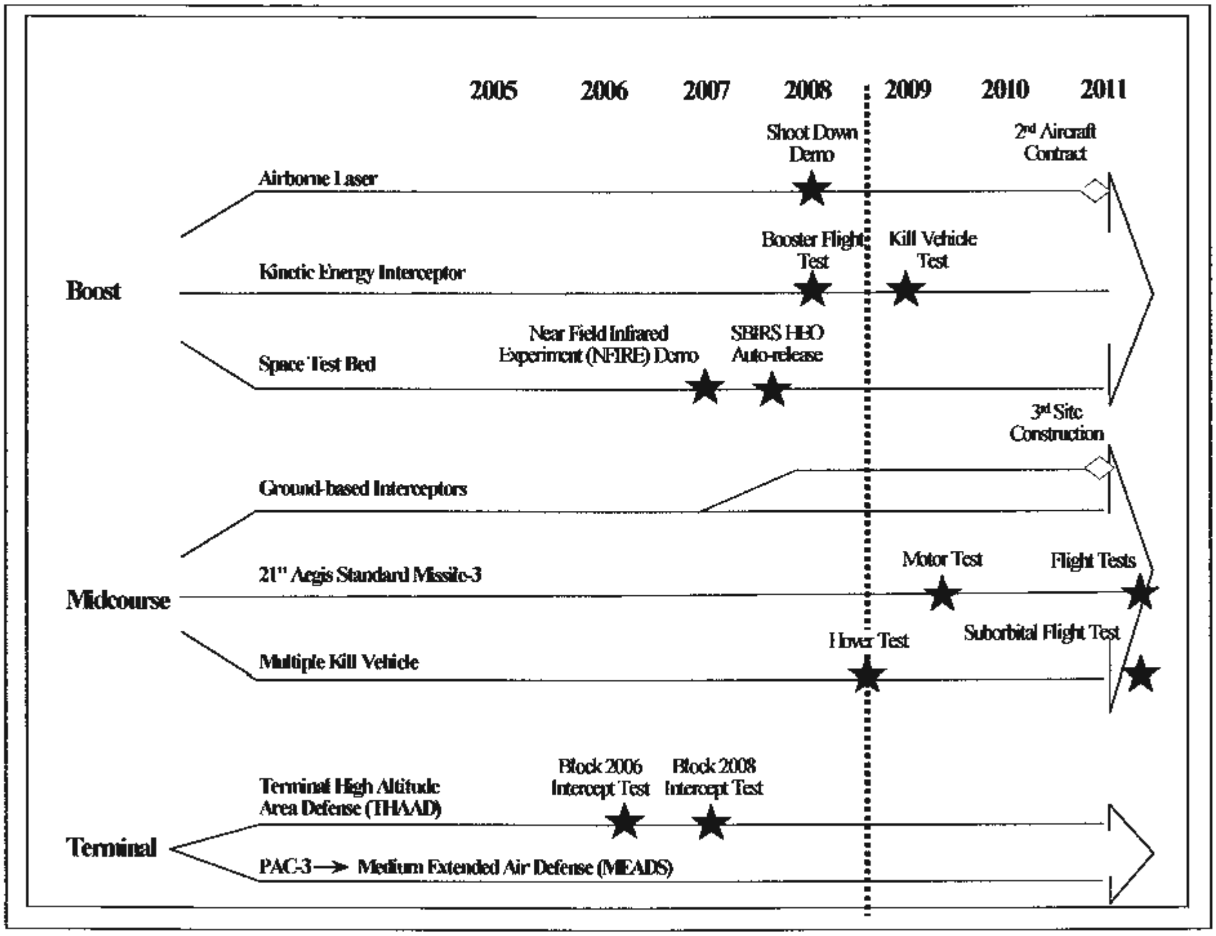


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**Figure I.1 Ballistic Missile Defense System Knowledge Points (U)**

- (U) Part of the knowledge point decision process is incremental refinement of the performance and cost estimates, and the concepts of operation reflected in this report. The user community and the United States Strategic Command will participate with the Missile Defense Agency Director in this decision process. Our out-year estimates will be refined as the elements reach their knowledge-based decision points, the technical designs mature, potential fielding quantities are determined, and concepts of employment and operation are defined and vetted with the user communities.

- (U) Tables I.3 through I.5 below summarize the estimated costs and investment through the fiscal year 2008 decision points for the three elements. For each element, the development cost estimates represent remaining costs, from fiscal year 2006, to complete development of the operational capability that is reflected in this report. The expected operational capability timeframe for each element is noted in each table. The fielding cost estimates are based on a cost per unit basis and the operation and support cost estimates are based on a cost per unit per year basis.

(b)(5)

[redacted]

(b)(5)

[redacted]

(b)(5)

[redacted]

## II. Background (U)

### Introduction: (U)

(U) The integrated Ballistic Missile Defense System is based on intercepting ballistic missiles and their reentry vehicles at all stages of their flight, in a multilayered approach, from just after launch through reentry as depicted in Figure II.1.

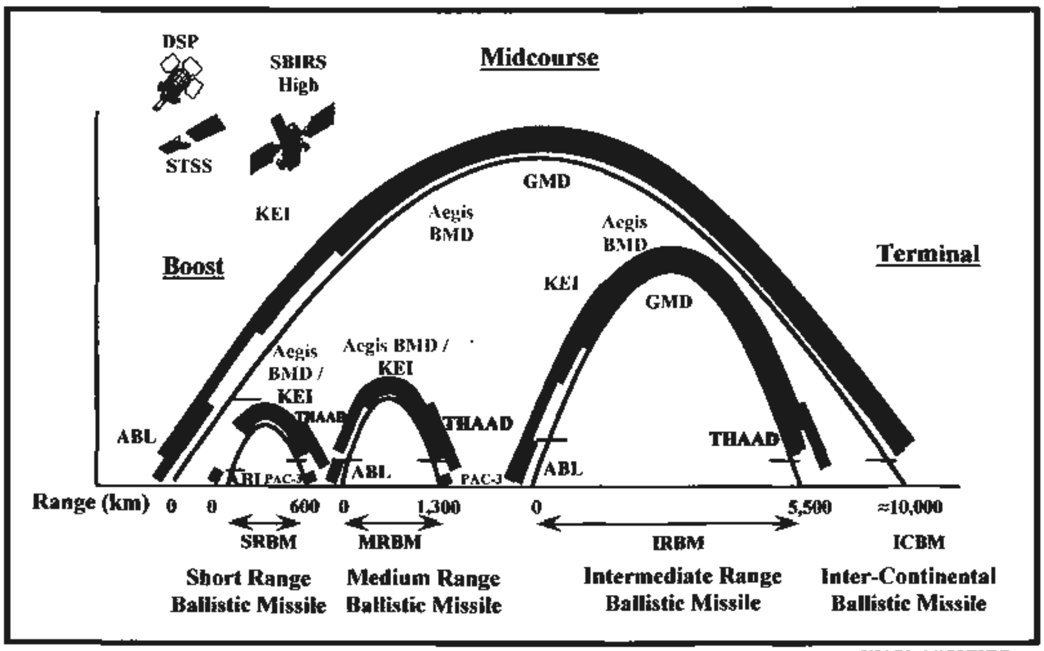


**Figure II.1 Layered Defenses, Beyond Block 2010 (U)**

### Layered Defenses (U)

(U) A layered defense provides three main benefits:

1. (U) Multiple shot opportunities: A layered defense provides multiple shot opportunities under different engagement conditions which improve the probability that a specific launch will be negated.
2. (U) Progressively reduced engagement size and complexity: Engagements in earlier layers generally make engagements easier for subsequent layers; both by progressively reducing or "thinning" a large number of ballistic missiles launched over a short time period; and by intercepting ballistic missiles prior to the deployment of countermeasures which could potentially complicate engagements by, and degrade the performance of, subsequent defensive layers.
3. (U) Exploits a range of adversary vulnerabilities: As a ballistic missile flies from its launch point toward its intended target, it has changing characteristics that pose different challenges to a defensive system but also reveal different

vulnerabilities throughout the flight. This allows the defense to take different approaches to detect, track, and negate the ballistic missile during the different phases of its flight, thus providing a more robust defensive system that is less sensitive, as a whole, to countermeasures. This flexibility is especially important given the uncertainties in the evolving capabilities of potential adversaries.

(U) The first opportunity to engage a ballistic missile is the relatively short period during the boost phase, when the ballistic missile's booster stages are still thrusting. Boost phase intercept can contribute significant capability to the multilayered Ballistic Missile Defense System, but this contribution is within the geographic and timeline constraints that are inherent to boost phase intercept. Adding a boost phase intercept layer can also both shape and limit an adversary's offensive missile capability by forcing launchers into deep interior areas in an attempt to avoid boost phase intercept and thereby reducing the reach of its ballistic missiles. If boost phase countermeasures are attempted, then the adversary's maximum missile range and payload capability would be further reduced.

(U) A second intercept layer might operate in what is called the ascent phase, that period of ballistic missile flight where the booster stages have stopped thrusting and have dropped away, leaving a reentry vehicle or in some cases a post boost vehicle which carries the warhead(s) and possible decoys or other countermeasures that can be dispensed by the post boost vehicle. Extending intercepts into the early ascent phase soon after ICBM booster burnout can potentially significantly increase intercept opportunities both in terms of the available intercept time and distance.

(U) Following the ascent phase is the midcourse phase which can last for tens of minutes. During this phase, the reentry vehicle and any countermeasures coast on ballistic trajectories towards their targets. A boost and ascent phase intercept capability can also synergistically enhance the defensive capability of the midcourse intercept layer. The potential for a boost or early ascent phase intercept could force an adversary toward quick payload deployment to avoid having the warhead destroyed while it is still attached to the hot, highly-visible booster upper stage. This quick deployment could also enhance the capability of the midcourse layer by precluding the delayed release over an extended period of time of complex decoy clusters which have been suggested as countermeasures to midcourse intercept. Early deployment also increases the likelihood that the adversary deploys within the field of view of forward deployed sensors which greatly improves midcourse defense capabilities. Additionally, any ICBM boost phase maneuvers or boost phase decoys an adversary might employ in an attempt to evade boost intercept could reduce payload available for any countermeasures against the subsequent midcourse and terminal layers.

**Properties of the Boost and Ascent Phases (U)**

(U) During the boost phase, the hot gases in the ballistic missile's booster exhaust produce a large infrared signature that is easily detected by overhead sensors as the rocket rises above the lower parts of the atmosphere. This phase typically lasts for three to five minutes for ICBMs. How much of this boost period is available for attack by defensive systems depends on how quickly the ballistic missile can be detected, how soon an engagement solution can be generated, and how fast the defense can deliver destructive energy onto the target.

(U) There is a range of kill mechanisms available during the boost phase that the defense can take advantage of to keep lethal effects from impacting the designated target. Directed energy solutions use laser energy to destroy the ICBM booster motor while it is still accelerating and directing the ICBM, and before the payload reaches its ballistic trajectory. As a result of booster destruction, the ICBM payload would not reach its intended target. Additionally, ICBMs typically fuse the warhead after the boost phase. Therefore, destruction of the booster during boost phase will likely disrupt the arming sequence and disable the warhead. Alternatively, kinetic hit-to-kill weapons have enough energy to destroy the ICBM payload at intercept. Therefore, the payload section is targeted during boost phase intercepts. If the kinetic weapon hits the booster instead of the payload, the results of the kinetic engagement would be the same as described for the directed energy weapon.

(U) Although the ballistic missile is relatively vulnerable in the boost phase, the short window of time available for intercept and the dynamic nature of a boosting target pose challenges to any boost phase system. As the ballistic missile travels through the boost phase, it is accelerating which makes exact prediction of its trajectory very difficult until late in the boost phase. Because laser systems deliver energy to the target at the speed of light, they are less sensitive to this uncertainty. Once the ballistic missile is detected and tracked by a laser weapon, the resulting time to deposit enough energy on the target to bring it to failure can be relatively short as compared to a kinetic weapon. The time required to deposit a lethal amount of laser energy would depend on the distance from the Airborne Laser to the target, the altitude of the target, the atmospheric transmission conditions, the geometry of the engagement, and the Airborne Laser performance (e.g., power output, maximum lase time, and beam jitter).

(U) However, kinetic energy weapons must account for the time needed to fly the interceptor to the intended target. Therefore, the defensive system must estimate the trajectory and future position of the boosting target at the projected time of intercept. Because the boosting target has a constantly changing velocity, this future trajectory prediction can contain large errors at the time of interceptor launch. Kinetic energy systems must account for this uncertainty by having enough maneuvering capability to react to and correct for this predicted intercept point error during flight.

(U) Ascent intercepts share many of the same payoffs associated with the boost phase; however, this leverage changes as the adversary missile booster or post boost vehicle dispenses its reentry vehicle(s) and any potential countermeasures. The duration of the ascent phase is dictated by the characteristics (either intentional or unintentional) of the adversary's ballistic missile and can vary widely. Intentional early reentry vehicle(s) and countermeasures deployment would cause some degradation in reentry vehicle accuracy but is potentially feasible if the adversary is targeting a large metropolitan area. During this phase, the attacking missile may be coasting or may adjust its attitude and velocity to *aim or prepare to dispense its reentry vehicle(s), decoys and any other countermeasures.* An ICBM warhead could be vulnerable to intercept (b)(5) [redacted] and the payload section is still generally easy to detect at this point with infrared sensors on interceptor kill vehicles. However, during the transition from boost to ascent phase, both the target characteristics and the range of kill mechanisms change; shifting from intercepting a relatively large and vulnerable thrusting booster stage to destroying a smaller payload section with one or more reentry vehicles attached.

**<u>Adversary Capability Overview (U)</u>**

(U) The Ballistic Missile Defense System is initially focused on developing, demonstrating, and deploying capabilities to defeat ballistic missiles launched from rogue nations such as North Korea and Iran. Those two nations pose different geographic and geopolitical challenges. North Korea is a relatively small state, with a land area of roughly 90 thousand square kilometers (300 kilometers by 300 kilometers). It is surrounded on two sides by international waters, on the southern side by a United States ally, the Republic of Korea, and on the northern side by the People's Republic of China, with Japan nearby across the Sea of Japan. Therefore, for boost and ascent phase intercept systems, sea or air basing on or over the Sea of Japan or Yellow Sea and land basing in Japan or South Korea are plausible.

(U) In contrast, Iran is a relatively large state with land area of roughly 1.7 million square kilometers (2000 kilometers long by 1300 kilometers wide). Iran is surrounded on three sides by states with a history or a likelihood of being cautious about permitting United States deployments on their territory, but in a region with numerous United States friends and allies. Therefore, there are broad areas potentially available for stationing land-based (or airborne) boost phase intercept systems, but all have some geopolitical uncertainty. Potential sea-based operating areas include the Persian Gulf and, possibly, the Black Sea. Because the interior regions of Iran are typically 500 to 700 kilometers from the Iranian border, the intercept ranges required and the engagement timelines for intercepting ICBMs launched from Iran are significantly more challenging than for North Korea.

(b)(1)

[redacted]

(b)(1)

[redacted]

## III. Definition of Elements for Comparison (U)

(U) The Missile Defense Agency is currently developing and demonstrating three elements that are designed for boost or ascent phase. The Airborne Laser is pursuing a directed energy solution designed specifically for boost phase intercepts. The Kinetic Energy Interceptor is pursuing a hit-to-kill interceptor and integrates high performance booster and kill vehicle capabilities into an interceptor that will have both boost and ascent phase capability. The Missile Defense Agency is maintaining parallel development paths through fiscal year 2008 with these two elements to provide options for this critical boost layer capability. In addition, the agency is also on the path to develop an upgraded Block IIA version of the Aegis Ballistic Missile Defense element's Standard Missile-3 that will have ascent phase capability.

(U) The Airborne Laser uses new technology and is working now to build engineering, manufacturing, and integration knowledge in this new area in an initial aircraft configuration designated Tail 1. Tail 1 will have a rudimentary boost phase capability which will be demonstrated in a lethal intercept test planned for fiscal year 2008. After this demonstration, an operational capability, designated Tail 2 will be developed with advancements in directed energy technology. The Tail 2 configuration will initially demonstrate operational capability in the Block 2016 testbed with a fully tested operational capability in Block 2018. Airborne Laser boost phase performance estimates in this report are predicated on the expected Tail 2 operational capability achieved through the evolution of directed energy technology.

(U) The Kinetic Energy Interceptor integrates more mature, high performance capabilities. The program is currently gaining engineering and manufacturing knowledge on the key new performance enablers for kinetic boost phase capability; a high performance booster and fire control capability for accurate and timely prediction of ballistic missile trajectories. These capabilities will be demonstrated through a series of knowledge point tests leading to a fiscal year 2008 booster flight demonstration. The Kinetic Energy Interceptor will initially demonstrate land-mobile operational capability in the Block 2012 testbed and sea-mobile operational capability in the Block 2014 testbed, with fully tested operational capabilities in Block 2014 and Block 2016 respectively. Kinetic Energy Interceptor boost and ascent phase performance estimates in this report are predicated on proving out new booster and fire control capabilities and successfully integrating components into an operational configuration.

(U) Aegis Ballistic Missile Defense has operational versions of the SM-3 and SPY-1 radar that are currently fielded. This capability is evolving through spiral development and incremental capability improvements in the Aegis Ballistic Missile Defense Weapon System and the SM-3 missile and by taking advantage of other sensors in the Ballistic Missile Defense System. The program is currently working with Japan to determine work shares and reach mutual agreement on performance requirements for the SM-3 Block IIA configuration. Aegis Ballistic Missile Defense with the SM-3 Block IIA interceptor will initially demonstrate operational capability in the Block 2012 testbed with fully tested operational capability in Block 2014. Ascent phase performance estimates for the Aegis Ballistic Missile Defense/SM-3 Block IIA operational capability contained in this report are predicated on maximizing the kinematic potential of the SM-3, refinement of ascent phase fire control timelines, and finalization of mutual United States/Japanese design requirements for the operational capability.

(U) The knowledge points for each Ballistic Missile Defense System element are summarized below in Figure III.1.

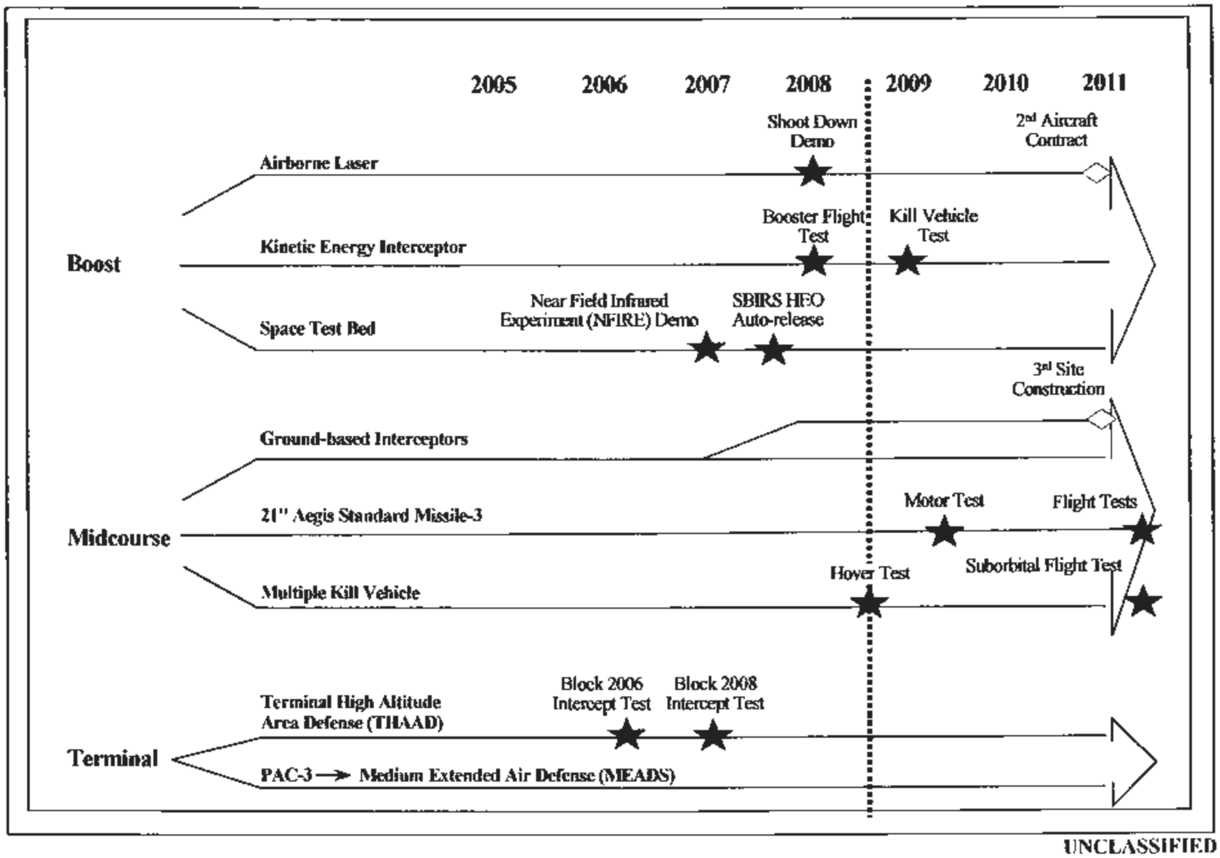


**Figure III.1 Ballistic Missile Defense System Knowledge Points (U)**

(U) This report examines all three of these Ballistic Missile Defense System elements in the context of boost and ascent phase capability. Table III.1 summarizes the characteristics of these elements.

(U//F) [redacted]

## Element Overviews (U)

(U) The following sub-sections provide an overview of these three elements.

### III.A. Airborne Laser Element Overview (U)

(U) The Airborne Laser (Figure III.A.1) element is designing, building, and testing an air-based laser system to acquire, track, and kill ballistic missiles of all ranges during the boost phase of flight. This includes a full range of capability to engage not just ICBMs, but also IRBMs, MRBMs, and SRBMs in the boost phase. Airborne Laser will be deployable within hours to any potential conflict, arriving in theater ready to provide an initial deterrent and defensive capability for the United States, deployed forces, and friends and allies.


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**Figure III.A.1 The Airborne Laser (U)**

(U) As shown in Figure III.A.2, Airborne Laser is a modified 747 commercial aircraft capable of operating at high altitudes for extended periods of time. The modifications include: (1) a megawatt-class high energy laser subsystem with large capacity laser fuel storage tanks; (2) an adaptive optics beam control system to fine track boosting ballistic missile targets, correct atmospheric disturbances, and stabilize the beam on the tracked target; (3) a nose-mounted 1.5-meter aperture beam director turret; (4) an avionics suite to provide robust Battle Management, Command, Control, Communications, Computers, and Intelligence (BMC4I) connectivity; (5) a passive and active infrared (IR) surveillance sensor suite to autonomously detect and track the boosting ballistic missiles; (6) a fully automated fire control system to prioritize and sequence multiple ballistic missile engagements; (7) an in-flight refueling system to support extended flight operations, and (8) enhanced aircraft subsystems, such as electrical and environmental control.

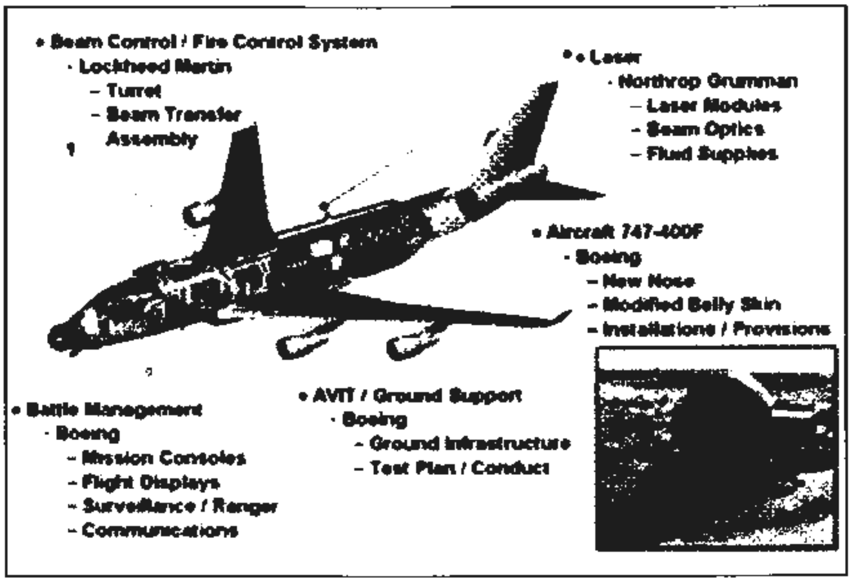


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**Figure III.A.2 Airborne Laser Program (U)**

(U) The Airborne Laser element achieved the important milestone of "First Light" on November 10, 2004, firing the six high energy laser modules simultaneously to produce photons. "First Light" was a critical milestone for the Airborne Laser element because it demonstrated the first integration of the laser hardware and control software necessary to generate photons. This achievement validated the physics underlying the chemical-oxygen iodine high energy laser design and verified that the laser was theoretically capable of generating and maintaining a megawatt-class laser beam. After "First Light" success, the Airborne Laser test effort progressed into an increasingly complex series of component and system-level tests, culminating in the final long-duration laser run in early December 2005. On December 9, 2005, after successfully operating the laser over 70 times, the element demonstrated the ability to reliably operate the laser for sufficient duration, and with enough power, to provide lethality at operationally significant ranges against all classes of ballistic missiles.

(U) The Airborne Laser element is on track to perform a lethal demonstration no earlier that CY 2008. Knowledge points have been established that will demonstrate incremental system capability, leading to the lethal demonstration. Design trades for a second aircraft with enhanced capabilities called "Tail 2" will start in 2009, during which the upgrade path from Tail 1 (the current Airborne Laser aircraft) to Tail 2 will be established. Current technology development efforts have shown significant gains in chemical-oxygen iodine laser efficiency improvement, illuminator laser power increases, and beam compensation techniques. These advances, combined with structural jitter reduction, provide the performance improvements that are expected to be achieved in the

Tail 2 Airborne Laser configuration. Table III.2 below summarizes the key performance improvements that are expected between Tail 1 and Tail 2 configurations.

(b)(1) [redacted]

**III.B. Kinetic Energy Interceptors Element Overview (U)**

(b)(1) [redacted]

(U) The Kinetic Energy Interceptors mission is to develop and field land and sea-based interceptor capabilities within an integrated Ballistic Missile Defense System that are cost-effective and have high mission assurance. Kinetic Energy Interceptors will exploit the benefits of mobility, early battlespace access, and distributed sensors to attack and defeat adversary ballistic missiles in new ways across the entire engagement space. The Kinetic Energy Interceptors' goal is to fill layered defense gaps, provide complementary capabilities to existing and planned systems, and provide a foundation for next generation systems to counter evolving adversary capabilities.

(U) The Kinetic Energy Interceptor element consists of a very fast, high acceleration interceptor, a mobile fire control and communications system, and a mobile launcher. These component designs are compatible with both land-mobile and sea-mobile operations. The interceptor features a high performance booster designed to carry multiple payload types. The Kinetic Energy Interceptor element is fully integrated into the Ballistic Missile Defense System and relies on external sensors for threat information. The element will leverage and build upon Ballistic Missile Defense System sensor and command control, battle management, and communication capabilities developed by other elements. The Kinetic Energy Interceptor design adheres to new Missile Defense Agency quality, safety, environmental and mission assurance standards and contains several unique design features including: direct downlink of overhead sensor data to a mobile weapon, advanced boost phase target tracking and prediction algorithms, a fast burning rocket motor with a high velocity at burnout, and a large divert capability that enables early weapon commits.

(U) Our plan is to develop both land-mobile and sea-mobile versions of the Kinetic Energy Interceptor system. We have planned up-front to maximize the commonality of the land-mobile and sea-mobile configurations. Having both basing modes expands the versatility of the Kinetic Energy Interceptor system and provides us the strategic and operational flexibility to dynamically layer the capabilities under different basing constraints and opportunity conditions. Figure II.B.1 below summarizes the Kinetic Energy Interceptor element.

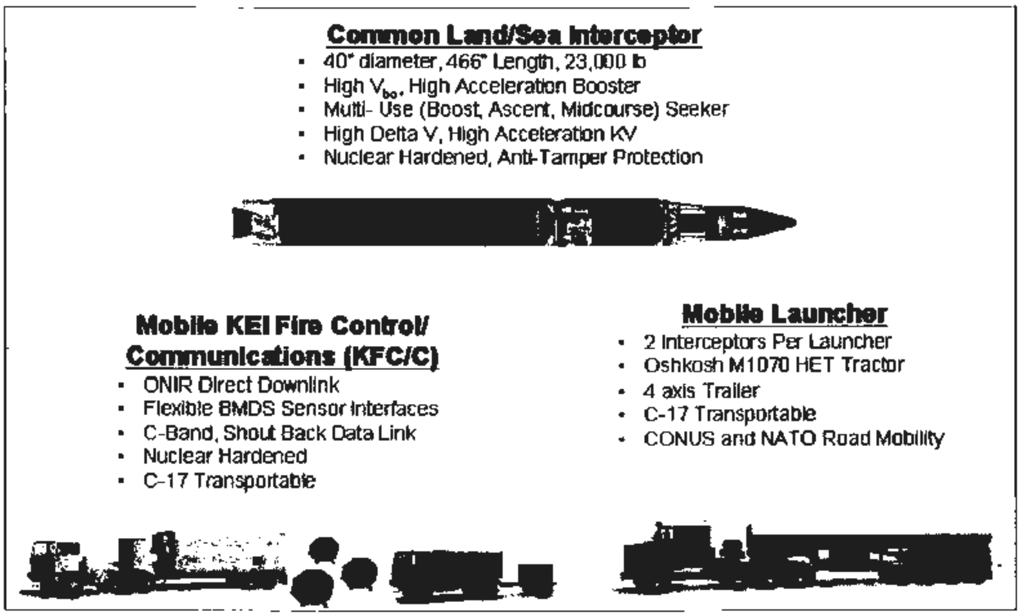


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**Figure III.B.1 Kinetic Energy Interceptor Element (U)**

(U) The Kinetic Energy Interceptor's near term emphasis is on component capability risk reduction and element engineering. The Agency's goal is to mitigate Kinetic Energy Interceptors critical risk areas prior to making full budget commitments. The performance, manufacturing, and cost knowledge we gain through fiscal year 2008 knowledge point tests will drive investment decisions including the path forward for the sea-mobile capability. Sea-mobile Kinetic Energy Interceptors is not funded currently in the Missile Defense budget beyond the approximate $10 million investment leading to the fiscal year 2008 knowledge-based decision point. The major knowledge point events include: 1) a campaign of real-time battle management and fire control tests with fully integrated Ballistic Missile Defense System Command, Control, Battle Management, and Communications and sensor capabilities to verify our quick response timeline and engagement sequences; and 2) a series of wind tunnel tests, booster first and second stage static firing tests and an integrated booster flight test to demonstrate booster capabilities. The booster design to be flown in the fiscal year 2008 flight test is traceable to our intended operational design. In addition to Kinetic Energy Interceptors execution performance, other Ballistic Missile Defense System investment priorities and threat evolution will dictate budget adjustments. At the knowledge-based decision points, the Missile Defense Agency Director will decide whether to continue the project as planned, terminate the effort, slow down the project, or accelerate the planned capabilities in pursuit of specific Test Bed or operational capability objectives.

### III.C. Aegis Ballistic Missile Defense Element Overview (U)

**Aegis Ballistic Missile Defense Mission (U)**

(U) The Aegis Ballistic Missile Defense (Aegis BMD) element of the Ballistic Missile Defense System provides the capability for selected United States Navy Aegis Cruisers and Destroyers to intercept and destroy ballistic missiles in the midcourse phase of the battlespace. Aegis Ballistic Missile Defense also provides surveillance and tracking functions against ICBMs for the Ballistic Missile Defense System Ground-based Midcourse Defense (GMD) element. Future iterations of Aegis Ballistic Missile Defense will include the ability to engage certain ballistic missiles in the ascent, midcourse, and terminal phases of flight. Figure III.C.1 below describes the Aegis Ballistic Missile Defense element.

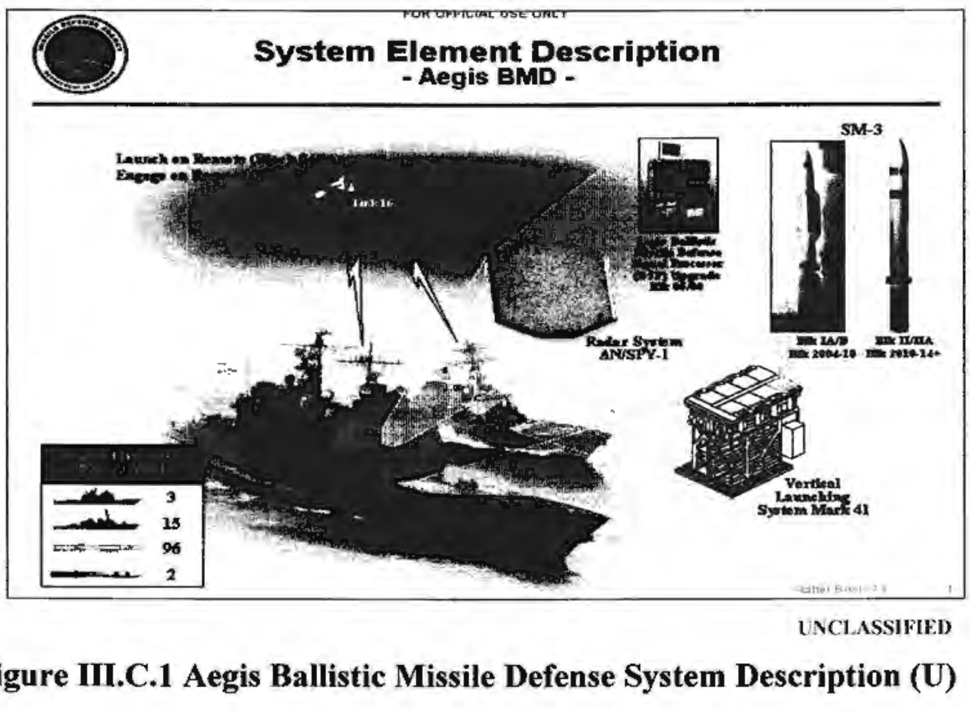


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**Figure III.C.1 Aegis Ballistic Missile Defense System Description (U)**

**Aegis Ballistic Missile Defense Block 2004 (U)**

(U) The Aegis Ballistic Missile Defense Block 2004 System has been brought into service to fulfill the sea-based portion of the initial missile defense capabilities. Aegis Ballistic Missile Defense Block 2004 contributes two major warfighting capabilities to the Ballistic Missile Defense System. The first capability is provided by Long Range Surveillance & Track (LRS&T) installations in Aegis Destroyers, which can search, detect and track ICBMs, and transmit the track data to the Ballistic Missile Defense System. This tracking data cues other Ballistic Missile Defense System sensors as well as assisting in the fire control solution of the Ground-based Midcourse Defense (GMD) system. Long Range Surveillance & Track was the first operational Aegis Ballistic Missile Defense capability. As part of the initial deployment of the Ballistic Missile Defense System, ten Aegis Destroyers assigned to the Pacific Fleet have been upgraded with the Long Range Surveillance & Track capability. A total of 15 Aegis Destroyers will receive the Long Range Surveillance & Track capability by the end of calendar year 2008 including two assigned to the Atlantic Fleet.

(U) The second Block 2004 Ballistic Missile Defense System warfighting capability provides the planning, detection, control, and engagement capabilities to defeat short and medium range ballistic missiles in the midcourse phase of flight with the SM-3 Block I and Block IA missiles. These capabilities are integrated into a weapon system configuration that includes the Long Range Surveillance & Track capability. An Aegis Cruiser, USS LAKE ERIE (CG 70), manned with fleet sailors and officers, is engaged in a series of firing missions to validate the operational capabilities of Aegis Ballistic Missile Defense against a progressively more complex set of targets and scenarios. To date, Aegis Ballistic Missile Defense has achieved six successful intercepts in seven firing tests. All 15 Aegis Destroyers scheduled to receive the Long Range Surveillance & Track capability will also receive the full deployment-certified computer program that includes the engagement and Long Range Surveillance & Track capabilities by the end of calendar year 2009.

**Future Aegis Ballistic Missile Defense Capabilities (U)**

(U) Future Aegis Ballistic Missile Defense capabilities are focused on enhanced system performance including improved sensor capability and a faster, longer range and more agile missile, as well as engagement coordination with other Ballistic Missile Defense System elements.

(U) Aegis Ballistic Missile Defense's improved sensor capability involves the SPY-1 radar's signal processor and the SM-3 kinetic warhead's IR seeker. Prototypes of both of these upgrades were tested in the firing mission, Flight Test Mission 04-1, conducted in February 2005 with the prototype seeker carried on an airborne sensor testbed aircraft. The Aegis Ballistic Missile Defense Signal Processor and two color seeker will provide both Aegis Ballistic Missile Defense and the Ballistic Missile Defense System with enhanced capability to identify objects and improve the probability of kill against a wider variety of ballistic missiles when these upgraded capabilities are fielded.

(U) The SM-3 Block II/IIA, will be co-developed with Japan. This missile builds upon the work performed in the Japan Cooperative Research (JCR) Project. The upgrade increases the range and velocity of the missile, providing reach, firepower, operational flexibility and performance; key warfighting objectives sought in the missile defense mission. With the addition of enhanced sensor performance, additional types of ballistic missiles can be engaged, with a greater probability of kill, and larger defended "footprint" or geographic area protected. The large missile magazine capacity of Aegis ships allows for multiple engagement opportunities. For a given defended region, fewer ships are needed to be employed in the Ballistic Missile Defense role due to the increased reach and firepower of the Aegis Ballistic Missile Defense SM-3 Block II/IIA when combined with the Ballistic Missile Defense System. The SM-3 Block II/IIA's performance will provide the necessary fly out acceleration to engage MRBMs, IRBMs, and certain ICBMs in the ascent, midcourse, and late midcourse phases.

## IV. Element Comparisons (U)

(U) The following sections compare the operational capability, basing options, asset requirements, and estimated cost of the elements under consideration in this report.

### IV.A Operational Capability Assessment (U)

(U) This section of the report describes the operational boost and ascent engagement capabilities of the individual elements considered in this report. We show examples of individual element performance in stand-alone scenarios to give the reader a sense of the individual contributions that each element could make to the multilayered Ballistic Missile Defense System. The reader should note that when deployed as part of the integrated multilayered Ballistic Missile Defense System, the various elements would be deployed in specific combinations and locations that best optimizes the total system performance.

#### Analysis Approach (U)

(U) In the following examples, we focus, as directed, on the capability in the boost and ascent phases to defend the United States against ICBM attack from North Korea and Iran. Additional element capabilities against shorter range ballistic missiles, for different defended regions, or for different engagement phases (midcourse and terminal) are not specifically addressed.

(U) We first show examples of expected stand-alone, single defense station, element capability to defend against a single launch of a representative ballistic missile. We then show the expected element capability with multiple stations for cases where more than one station is needed. Examples are shown of defensive performance sensitivity to variations in ballistic missile characteristics including: booster burn time (for liquid versus solid propellant ICBMs); multiple launches over a short period; and the duration of ballistic missile ascent phase prior to payload deployment.

(U) The measure of missile defense engagement capability we use in these examples is launch area denied (LAD); the potential ballistic missile launch area that the missile defense denies use of, or takes away from, an adversary. No ICBM launched from within the denied area would reach its intended aim point in the specified defended areas of the United States without being engaged by the boost and ascent phase defenses considered in this report.

**Boost Phase Engagement Capability (Airborne Laser and Kinetic Energy Interceptor) (U)**

(U) The Agency is developing boost phase engagement capabilities to defeat ICBMs in both the Airborne Laser and Kinetic Energy Interceptor elements.

**Airborne Laser Boost Phase Engagement Capability (U)**

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

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[redacted]

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(b)(1)

[redacted]

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

**Countermeasure Sensitivity (U)**

(U) The design process for the three elements with boost and /or ascent phase intercept capability takes into account the possibility that adversaries could employ some of the classes of potential countermeasures discussed in this section. Therefore, some initial provisions for resistance to the types of countermeasures each element is considered most likely to face are already being incorporated into the designs being developed and demonstrated. Future upgrades for enhanced robustness against countermeasures could be incorporated subsequently as warranted.

(U) Once an adversary achieved an initial ICBM capability, the presence of an effective boost phase defense layer could drive the adversary to pursue boost phase countermeasures. Table IV.A.1 below summarizes potential classes of technical countermeasures that an adversary could use to attempt to defeat a boost phase system and indicates which boost systems are sensitive to a class of countermeasures. A check mark indicates that the performance of the Airborne Laser or Kinetic Energy Interceptor could possibly be affected or degraded in the presence of that class of countermeasure.

The table shows that Airborne Laser and Kinetic Energy Interceptor complement each other because most of the classes of countermeasures only affect one system.

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1) [redacted]

(U) Some potential ascent phase intercept countermeasures are the same as countermeasures to boost phase engagement – separating the true position of the ballistic missile from the predicted intercept point towards which the interceptor has been sent by perturbing the ballistic missile trajectory: either axially through coasting between booster engine burns; or laterally by trajectory shaping maneuvers (doglegs) and end-of-boost energy management maneuvers.

(b)(1) [redacted]

(U) Other conceptual countermeasures specific to ascent phase are likely similar to those considered useful in midcourse and could include: releasing jammers and chaff (in sunlight) to deny off-board sensor tracks, releasing flares to saturate kill vehicle seekers, cluttering the scene with false targets (decoys), releasing tethered objects to deny aim point selection, or combinations. Because the duration of the ascent phase is much shorter than midcourse, these countermeasures could be more challenging.

## IV.B Basing Options (U)

(b)(1) [redacted]

(b)(1)

[redacted]

(b)(1) [redacted]

**Figure IV.B.2 Defensive Operating Areas for Boost and Ascent Intercepts (Iran) (U)**

## IV.C Operational Comparisons (U)

### Airborne Laser Deployment Operations (U)

(U) The Airborne Laser can be deployed rapidly to any potential conflict, arriving in theater ready to provide an initial United States deterrent and defensive capability for deploying United States and/or allied forces. The Airborne Laser will be fully interoperable with other weapon systems in the joint Ballistic Missile Defense System.

(b)(1) [redacted]

(U) Normally, Airborne Lasers will not be dispersed when deployed to a theater of operations. Use of peculiar maintenance and support equipment, as well as specialized skills to service the laser weapon system, suggests consolidation of these high value resources. An in-theater forward operating location will not require the full support infrastructure that the CONUS main base must have. In particular, laser test facilities to conduct ground tests are not required. Large support equipment will be air-mobile, palletized or consist of rolling stock (sized to fit a C-130 Cargo bay); the Airborne Laser itself will carry documentation and diagnostic instrumentation. Normal large-aircraft servicing such as heavy-load ramps and taxiways, 8,000+ ft runways, de-icing, aircraft fueling, maintenance stands, and cargo handling equipment are necessary, but may be available for use at an in-theater forward operating area. Consideration must be given to space requirements for a laser fueling area and laser fuel mixing/storage facilities that would be required to maintain the Airborne Laser refueling requirements. Properly maintained fuel may last up to two weeks if not utilized to fight. The Airborne Laser could maintain an orbit, preventing enemy launches for this duration without re-supply as long as no hostilities occur. Once hostilities start, refueling will be necessary. Current transportable laser fuel mixing prototypes have demonstrated the ability to create mixed chemicals which exceed the previous shelf life estimates, lasting up to 14 days.

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**Figure IV.C.1 Prototype Mixed-base Hydrogen Peroxide Systems (U)**

(U) When deploying, enroute air-to-air refueling may be necessary depending on the distance to the theater. When the Airborne Laser aircraft deploys it will require airlift to transport support personnel, equipment, and laser consumables to sustain theater operations, regardless of location.

**Kinetic Energy Interceptor Deployment Operations (U)**

(U) The Kinetic Energy Interceptor Fire Unit/Battery is part of the larger, integrated Ballistic Missile Defense System. Kinetic Energy Interceptor could be deployed as a part of a multi-level operation or deployed separately as a flexible deterrent option.

**Land-Mobile Kinetic Energy Interceptor Deployment Operations (U)**

(U) Upon alert notification, the land-mobile Kinetic Energy Interceptor element would deploy from CONUS to the desired location for operations. The Kinetic Energy Interceptor system is being designed to be deployed in a minimal time with minimal transportation assets and follow-on support. The fire unit/battery configuration presents a "building block" approach to deployment that can reduce the required deployment aircraft asset requirements depending upon the maturity of the theater and in-theater augmentation support available.

(U) The typical deployment sequence is expected to be a road march to a port of embarkation, followed by transport via air or sea to a port of debarkation, and finally road march to the operating location. The nominal deployment time from a CONUS site to Ready Alert status is two to three days including flying time.

(U) Normally, the Kinetic Energy Interceptor element would deploy with its full complement of two fire control and communications components, five launchers with 10 interceptors, and associated support and supply vehicles. This provides maximum redundancy and ensures continual system availability. If mission needs dictate, the element may deploy in smaller firing sections for additional agility and flexibility. Each firing section may consist of a single fire control and communications component, one or more launchers, two or more interceptors, and associated support and supply vehicles. A minimum engagement package could also be integrated into existing missile defenses of PATRIOT and/or Medium Extended Air Defense System (MEADS) to provide a task force with capabilities against a wide range of ballistic missiles.

(U) The core battery must be augmented with external support to provide command, force operations and sustainment operations. This external support represents key factors that must be considered during theater-specific deployment planning.

(U) Kinetic Energy Interceptor is expected to be deployed in friendly developed countries with an existing infrastructure. It will not be part of a force insertion into a hostile environment. Though mobile and transportable, subsequent moves of the Kinetic Energy Interceptor Battery are not anticipated. The intent is not to deploy Kinetic Energy Interceptor alone, but as part of an Air and Missile Defense Task Force (AMDTF) which is comprised of air and surface security/protection. Due to the politics of deployment, early Department of Defense and State Department negotiations must take place and site and route surveys conducted for pre-selected sites driven by adversary capability analyses. To reduce deployment and support logistics requirements and costs, host nation military and local commercial industrial support may be used and would require contractor participation in early deployment planning and survey teams. Concepts to use host country support will require user coordination and approval on a country-by-country basis.

(U) Air deployments are used for time sensitive contingency movements and are considered the desired deployment mode for Kinetic Energy Interceptor. The Kinetic Energy Interceptor Fire Unit/Battery deploys with a mix of airlift assets. The Kinetic Energy Interceptor Fire Unit/Battery vehicles and equipment are capable of roll-on/roll-off loading on USAF C-17 and C-5 aircraft. Due to size and weight constraints, the Kinetic Energy Interceptor launchers can only deploy by C-17, C-5A or civilian equivalent. The system components of the element can be deployed on nine C-17 or seven C-5 aircraft. The element support vehicles and equipment will require additional airlift. If a rapid insertion capability is required, a minimum engagement package consisting of a single fire control and communications component and two launchers with four interceptors can be deployed on four C-17 or three C-5 aircraft.

(U) Sea movement can be used for non-time sensitive deployments. Maritime movements can be made by both roll-on/roll-off ships and in load-on/load-off ships. Selected Kinetic Energy Interceptor equipment must be prepared for ship movement and capable of being set up and secured to the deck of a ship.

**Sea-Mobile Kinetic Energy Interceptor Deployment Operations (U)**

(U) The Navy's forward operating posture is well suited to the prospective Kinetic Energy Interceptor mission. Traditional Navy operating patterns feature rotational deployments to the very areas where such missions might well be called for by Combatant Commanders. The necessary infrastructure to sustain Navy forces indefinitely is already in place.

(U) The Kinetic Energy Interceptor is designed as a common land/sea all-up round (interceptor and canister). The interceptor dimensions and safety features such as a gas eject launch make it compatible with surface combatants, submarines, and large non-combatant ships. The Kinetic Energy Interceptor sea-mobile element involves integrating the common all-up round into a surface and/or sub-surface platform.

(U) The Kinetic Energy Interceptor sea-mobile concept has not yet been fully defined. The Missile Defense Agency and the Navy have jointly studied the concept of operations and feasibility of various ship platforms for both the Kinetic Energy Interceptor boost/ascent mission and the Kinetic Energy Interceptor midcourse mission. In fiscal year 2006 and 2007 we will continue our joint efforts to conduct a comprehensive alternatives assessment of viable sea-mobile platforms. The study group will recommend a platform strategy allowing us to begin platform-specific planning, system engineering, and risk reduction to facilitate a smooth and rapid start of a future sea-mobile development and test phase.

**Aegis Ballistic Missile Defense Deployment Operations (U)**

(U) SM-3 Block IIA missiles are part of a tightly coupled Aegis BMD Weapons System that includes the SPY-1 radar, the Mk 41 Vertical Launching System, and the Command & Decision and Weapons Control System computers. As such, they will be deployed in in-service Navy warships. Combatant Commander (COCOM), United States Navy or other Department of Defense policy regarding worldwide apportionment of SM-3 Block IIA missiles will set theater presence requirements for various numbers of SM-3 Block IIA missiles to meet Regional and Functional COCOM contingency requirements. Operational orders will be updated to specify detailed command and control relationships and readiness conditions (for a measured response). Based on these numerical requirements, Aegis BMD configured ships with requisite quantities of SM-3 Block IIA will be assigned to Combatant Commanders as dictated in operations plans or through Request for Force (RFF) procedures. These plans will specify numbers of ships and missiles required for a given contingency, as well as operating areas, enemy courses of action and other information which will allow for basic planning. Indications and Warning (I&W) will dictate degree of response in a given scenario. Appropriate numbers of Aegis BMD ships loaded with SM-3 Block IIA will be on station at a time of crisis, or within an appropriate number of hours of transit distance allowed by operational plan.

(U) Assigning BMD missions to Aegis BMD ships loaded out with SM-3 Block IIA missiles is compatible with and complementary to the conduct of other, traditional Aegis ship missions including tactical strike, area and own ship air defense, anti-surface, and anti-subsurface. Aegis Ballistic Missile Defense ships will be able to conduct the full range of ballistic missile defense missions from pre-launch/pre-boost (Tomahawk Land Attack Missile), boost phase (SPY-1 Long Range Surveillance & Track), and ascent, midcourse, and descent phase (SM-3 Block II/IIA and SM-3 Block IA/IB – dependent on threat missile type) while defending themselves against air, surface, and subsurface attack.

## IV.D Operational Asset Comparison (U)

(U) All of these elements are early in their development. Their operational concepts are not mature, and have not been fully vetted within the user communities. Limited analysis and data exists on operational asset requirements. This section of the report summarizes what is currently known for these systems concerning the number of assets that are required to maintain continuous coverage at a single station.

### Airborne Laser (U)

(U) Airborne Laser requires at least three aircraft for a near-continuous single combat air patrol station. More may be required depending on the length of deployment, capabilities of the aircraft available, and whether or not the Combatant Commander needs near-continuous or continuous coverage. The specific quantity of operational assets required for deployment periods of seven days, thirty days, ninety days and one year have not yet been determined.

(U) There are at least three ways that an Airborne Laser could be employed. The first is by providing a sustained combat air patrol to negate any ballistic missile launches over an extended period of time. Second, Airborne Laser could be used as a sensor only platform. Finally, the Airborne Laser could be used as part of a preplanned strike package designed to eliminate ballistic missiles on the ground where Airborne Laser would defend against last-minute adversary ballistic missile launches. In this scenario, the Airborne Laser could be put on station for a shorter period of time because the event timing would be dictated more by intelligence information and by our actions than by the actions of the adversary.

**<u>Kinetic Energy Interceptor Land-Mobile (U)</u>**

(U) The land-mobile Kinetic Energy Interceptor element is being developed to be mobile yet sustainable over long periods of time. Each Kinetic Energy Interceptor land-mobile unit will have dual-redundant fire control and communications systems that will help maintain a high state of readiness and availability. Single station coverage can be sustained by one Kinetic Energy Interceptor Unit for an indefinite period of time at its rated availability.

**<u>Kinetic Energy Interceptor Sea-Mobile (U)</u>**

(U) The Kinetic Energy Interceptor sea-mobile concept is still being defined; however, some preliminary analysis has been conducted. The joint Missile Defense Agency-Navy 2005 Midcourse Intercept Concept of Operations and Feasibility Study assessed the force structure impacts of providing Kinetic Energy Interceptor capability in a 24 hours per day, seven days per week, 365 days per year context with 100 percent availability from various Navy platforms. This assessment is applicable for a 365 day and greater deployment duration for ships and submarines, as appropriate. A total of four Kinetic Energy Interceptor-modified surface combatants or three Kinetic Energy Interceptor-modified submarine assets were required to maintain continuous coverage for one year. Asset requirements for shorter time periods such as seven days, 30 days, or 90 days, have not been evaluated. A lesser number of sea-mobile Kinetic Energy Interceptor platforms, down to even one, would provide some level of a contingency sea-mobile capability; however the actual overall availability is not known, a specific employment plan was not developed, and the unintended consequences of partial capabilities to both homeland missile defense missions and other Navy missions are not known at this time.

(U) The study assumed that at least one platform was in-theater and on-station with 24 hours per day, seven days per week coverage at all times. The assets are considered to be dedicated for the Kinetic Energy Interceptor mission and may no longer be available for other Navy missions. The assumed unique deployment scheduling (not current Navy practice) required the fewest number of platform conversions for Kinetic Energy Interceptor, but resulted in the greatest impact to other Navy fleet operations.

(U) The exact status of each platform changes as a function of time, and therefore it is not possible to state a static decomposition of the platforms. However, it is reasonable to explain the surface ship makeup as one in home port, one in transit, one in theater and one in-theater <u>and</u> on-station. Similarly for subs, it is reasonable to think of the mix as being one in port or transit, one in transit or in theater and one in theater and on-station. There will be short periods when two platforms will be in-theater and on-station. However, limiting the number of platforms that are on-station (100 percent available and ready to go) to a maximum of one at any given time does not decrease the total number of platforms required.

(U) Less than 24 hours per day, seven days per week availability (around 76% for subs and 87% for ships) can be achieved if fewer ships could be used, for example two ships and two subs.

**Aegis Ballistic Missile Defense with SM-3 Block IIA (U)**

(U) The number of SM-3 Block IIA equipped Aegis ships required to maintain continuous ascent phase intercept coverage would be similar to the number required for sea-mobile Kinetic Energy Interceptor. Aegis ship requirements would also be comparable to the number of assets required to fill the Ballistic Missile Defense patrol area in support of the long-range surveillance and track mission currently being performed by the Navy. The specific quantity of operational assets required for deployment periods of seven days, thirty days, ninety days and one year have not yet been determined.

## IV.E Cost Comparison (U)

(b)(5)

[redacted]

(U) Part of the knowledge point decision process is incremental refinement of the performance and cost estimates, and the concepts of operation reflected in this report. The user community and the United States Strategic Command will participate with the Missile Defense Agency Director in this decision process. Our out-year estimates will be refined as the elements reach their knowledge-based decision points, the technical designs mature, potential fielding quantities are determined, and concepts of employment and operation are defined and vetted with the user communities.

(U) Table IV.E.1 summarizes the development cost, fielding average unit cost (FAUC), and average unit operations and support (AUO&S) cost per year estimates for the systems discussed in this report. The estimated cost numbers shown here are for analysis use only and should not be used for any other purpose. These are forward looking cost estimates and subject to known and unknown risks, uncertainties, and other factors which could cause the actual costs to differ from estimated future results. All costs are presented in constant base-year fiscal year 2006 dollars. Fiscal year 2005 and prior costs are not included for any program. Estimates are provided in ranges to reflect the inherent uncertainties in the numbers. The fielding average unit cost includes all costs associated with producing a number of units divided by that number of units. The average unit operations and support cost per year represents the steady state annual support cost divided by the number of units. The AUO&S estimates reflect peacetime maintenance and training costs, and do not include the costs associated with wartime deployments, force protection where required, or host nation infrastructure where required.

(b)(5)

[redacted]

(U) Table IV.E.2 provides the definition for a single unit for each element that was used in developing the FAUC and AUO&S.

**Table IV.E.2 UNIT DEFINITIONS (U)**

| BMDS Element | Unit Definition |
|---|---|
| **Airborne Laser** | 1 Aircraft |
| **Kinetic Energy Interceptor** | 2 Fire Control and Communications, 5 Launchers, 10 Missiles, 1 Set of Ship Modifications where applicable |
| **Aegis Ballistic Missile Defense SM-3 Block IIA** | 1 Set of Ship Modifications, 10 Missiles |

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## Airborne Laser Cost Estimates (U)

(U) The development cost estimate for Airborne Laser includes: remaining development costs associated with the "Tail-1" effort and "Tail-2" second aircraft capability which includes the acquisition of the Tail-1 and Tail-2 aircraft, testing, and all contractor and government support costs. The Tail-2 program estimate includes costs associated with aircraft and laser modifications and improvements, beam control and fire control enhancements and optimization, mission systems enhancements and optimization, and logistics and supportability improvements.

(U) Additionally, there may be adjustments to incorporation of various technologies as additional engineering and cost analysis are performed in future iterations of the overall technical evaluation of the Airborne Laser system and the Ballistic Missile Defense System operational needs and requirements. The Tail-2 aircraft will incorporate these modifications and improvements to the Airborne Laser system for inclusion into subsequent fielding. These modifications and improvements are under continuous evaluation, including affordability considerations; changes to the scope of these adjustments may result in higher or lower costs.

(U) The fielding average unit cost is based on a nominal fielding run of seven aircraft at a nominal fielding rate of two per year. A projected reduction to fielding costs associated with a producibility effort is included in the development program.

(U) The operations and support unit cost per year includes maintenance and training costs for a nominal fleet of seven aircraft with operations from a single main operating base located in the United States.

**Kinetic Energy Interceptor Cost Estimates (U)**

(U) The land-mobile Kinetic Energy Interceptor development cost estimate captures all remaining costs associated with the current development and test baseline for the multi-use boost, ascent, and midcourse capability, Missile Defense Agency enhanced requirements for survivability, mission assurance and information assurance, testing, and all contractor and government costs.

(U) For this report, a Kinetic Energy Interceptor unit is defined as two fire control and communications components, five launchers, ten interceptors, and one set of ship modifications where applicable. For the FAUC, the cost is based on the negotiated component unit price (CUP) costs included as options to the development contract for the interceptor, fire control and communication, and launcher components. Ship modifications were not part of the negotiated component unit price costs; these costs include: launcher modifications, integration and safety testing, and minimal integration of the fire control and communications components into the existing ship weapons control system.

(U) An alternatives assessment study was initiated in February 2006 to identify the specific platforms for a sea-mobile Kinetic Energy Interceptor capability and lay out in more detail the work that would have to be performed; results of the study will be available next year. The estimate provided for this report for the sea-mobile capability captures two prospective platforms, a representative surface combatant and submarine, and assumes the land-mobile program proceeds as planned. This surface combatant estimate assumes the modification of an existing CG-52 class ship, including the removal and replacement of one of the two 64-cell MK 41 Vertical Launching System (VLS) on the ship, hypergolic fuel monitoring and containment, integration onto the ship of the Kinetic Energy Interceptors fire control and communications components, and the modification occurring during a shipyard availability period. Minimal Aegis Weapon System integration will be performed. The alternatives assessment may result in the selection of a different ship or design concept for a Kinetic Energy Interceptor surface ship with either higher or lower costs associated with it.

(U) The alternatives assessment study will also include submarine platforms among the alternatives. This estimate assumes the modification of an existing SSGN class ship, including the conversion of ten launch tubes, minimal integration into the SSGN's weapons control system, hypergolic fuel monitoring and containment, and the modification occurring during a shipyard availability period. The Kinetic Energy Interceptors fire control and communications components will be integrated into a CG-52 class ship with minimal Aegis Weapon System integration. The alternatives assessment may result in the selection of a different submarine or design concept for a Kinetic Energy Interceptor submarine with either higher or lower costs associated with it.

(U) At this time, the Kinetic Energy Interceptor AUO&S has been estimated only for the land-mobile program. The first ten years of contractor and depot level support are covered by warranty, the price for which is included in the negotiated component unit price costs. Other support costs such as mission personnel and government cost are included.

**Aegis Ballistic Missile Defense Cost Estimates (U)**

(U) The development cost estimate for Aegis Ballistic Missile Defense includes development of the SM-3 Block IB, Block II, and Block IIA missile variants. The SM-3 Block II and Block IIA development is planned to be conducted jointly with Japan; the expected Japanese work contribution will lower the overall cost for the United States by approximately $1 billion. The development includes several ship computer baselines that are spirally developed in order to achieve the final configuration, development of the Ballistic Missile Defense Signal Processor, transition of software to Open Architecture, and Launch on Boost capability. These estimates also assume the United States Navy fully finds their modernization effort.

(U) For this report, an Aegis BMD unit is defined as ten SM-3 Block IIA missiles and one set of ship modifications. For the FAUC, the missile cost is based on a nominal fielding run of 96 missiles at a nominal fielding rate of two per month. Ship modifications include: installation of the computer program baselines, Aegis BMD Signal Processor, Missile Downlink System, and related ship and ordnance alterations.

(U) The AUO&S estimate includes: missile defense mission-related incremental support costs, SM-3 Block IIA missile maintenance cost, Aegis computer program baseline maintenance. Normal ship operating costs are not included as these costs would be incurred regardless of the missile defense mission. Note that force protection would not be required for an Aegis Ballistic Missile Defense ship.

**IV.F Other Capabilities (U)**

(U) Although not the directed focus of this report, each element that is considered here has capabilities beyond just boost and ascent phase ICBM defense that contribute across the Ballistic Missile Defense System mission. All three elements provide complementary capabilities and contribute in different ways to the integrated multilayered Ballistic Missile Defense System. They all will have the capability to engage some ballistic missiles with shorter ranges than ICBMs and can contribute to the defense of United States friends and allies. The Airborne Laser will have a unique capability to engage large numbers of early generation ballistic missiles of all ranges in the boost phase including shorter range ballistic missiles that remain within the atmosphere. Both the Kinetic Energy Interceptor and SM-3 Block IIA will have midcourse phase intercept capability. Kinetic Energy Interceptor's booster also provides a common booster for additional future capabilities such as the Multiple Kill Vehicle and other advanced payloads that are currently being studied.

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# Appendix A: Analysis Approach and Assumptions (U)

# Appendix A: Analysis Approach and Assumptions (U)

## A.1 Assumptions For Defended Area and Launch Area Denied Analysis (U)

(U) To support the analysis, ballistic missile trajectories were generated from a representative set of launch points that geographically span the range of potential launch points to a set of aim points that similarly geographically span the range of potential aim points. Five points where chosen to bound the launch points from North Korea, and seven points where chosen to bound the Iranian launch points as shown in Figure A.1. Ballistic missile trajectories were flown from these bounding launch points into 16 points chosen to geographically span the range of aim points within the United States.

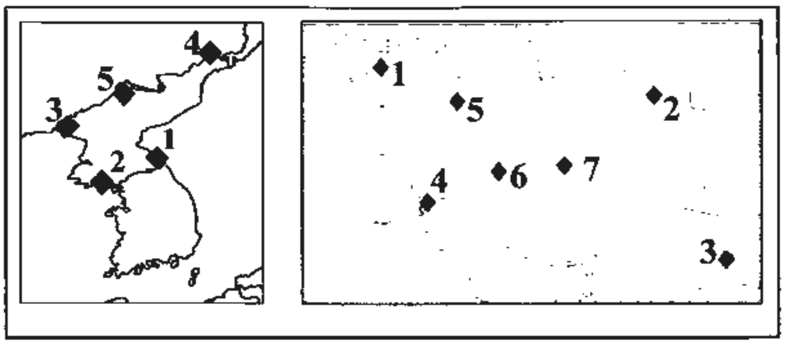

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**Figure A.1 Bounding Sets of Launch Locations in North Korea and Iran (U)**

(U) One measure of missile defense capability used in this report is launch area denied (LAD); the potential ballistic missile launch area that the missile defense denies use of, or takes away from, an adversary. No ICBM launched from within the denied area would reach its intended aim point in the specified defended areas of the United States without being engaged by the boost and ascent phase defenses considered in this report. A map point is included in the launch area denied if the defense, deployed at specified stations and operating by certain rules, could intercept an ICBM, flown to any of a specified set of United States aim points, before burnout or the end of ascent phase. For this report, the aim point set that is to be defended can be either all of the United States or specific parts of it (e.g., east or west coast of CONUS or Hawaii or Alaska). Whether the defense can make an intercept depends on the ballistic missile trajectory and on what aim point the ballistic missile is attacking as well as on detection times, required track accuracies, decision times, and either interceptor fly out times or high energy laser irradiance times.

(U) For the launch area denied analysis, for a specified defense element location, the defensive element was analyzed against liquid and solid propellant ICBMs launched from all possible launch points on a 1° x 1° latitude and longitude grid covering the adversary territory and targeting the United States bounding aim point set discussed above. A launch grid point is deemed denied only if all aim points are defended.

### A.2 Adversary ICBM Assumptions (U)

(b)(1)

[redacted]

### A.3 Other Analysis Assumptions (U)

(b)(1)

[redacted]

(U) Additional defense elements necessary to defend the boost and ascent phase elements were assumed present and adequate. These might include Terminal High Altitude Area Defense (THAAD) or PATRIOT or both for the Kinetic Energy Interceptor; Aegis Weapon System self defense capability, and combat air patrols for the Airborne Laser.

(b)(1)

[redacted]

# Appendix B: Letters to Congressional Oversight Committees (U)

# Appendix B: Letters to Congressional Oversight Committees (U)

## B.1 (U) Letter to Chairman, Committee on Appropriations, U.S. Senate

**DEPARTMENT OF DEFENSE**
**MISSILE DEFENSE AGENCY**
**7100 DEFENSE PENTAGON**
**WASHINGTON, DC 20301-7100**

MAY 30 2006

The Honorable Ted Stevens
Chairman
Subcommittee on Defense
Committee on Appropriations
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

The House Appropriations Committee report (H.Rept.109-119) to accompany H.R. 2863, the Department of Defense Appropriations Act, 2006 directs the Secretary of Defense to conduct a joint study with the Government Accountability Office (GAO) to review the early engagement of ballistic missiles to include boost and ascent phase intercepts.

The committee directed that the report be provided no later than 90 days after the enactment of Department of Defense Appropriations Act, 2006 and specifically include but not be limited to the following: (1) An assessment of the operational capabilities of systems against ballistic missiles launched from North Korea or a location in the Middle East against the continental United States, Alaska, or Hawaii; (2) An assessment of the quantity of operational assets required for deployment periods of seven days, thirty days, ninety days and one year; (3) Basing options; and (4) An assessment of life-cycle costs to include research and development efforts, procurement, deployment, operating and infrastructure costs.

The Missile Defense Agency will prepare and submit this report on behalf of the Secretary of Defense. Note that since the GAO is an independent review agency; they have declined to participate in a joint study. When complete, I will prepare the report to the defense committees. A similar letter is being sent to the Chairmen and Ranking Members of the other congressional defense oversight committees.

Sincerely,

HENRY A. OBERING III
Lieutenant General, USAF
Director

cc:
The Honorable Daniel K. Inouye
Ranking Member

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## B.2 (U) Letter to Chairman, Committee on Appropriations, U.S. House of Representatives

**DEPARTMENT OF DEFENSE**
**MISSILE DEFENSE AGENCY**
**7100 DEFENSE PENTAGON**
**WASHINGTON, DC 20301-7100**

[illegible] 3[illegible] 2006

The Honorable C.W. "Bill" Young
Chairman
Subcommittee on Defense
Committee on Appropriations
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

The House Appropriations Committee report (H.Rept.109-119) to accompany H.R. 2863, the Department of Defense Appropriations Act, 2006 directs the Secretary of Defense to conduct a joint study with the Government Accountability Office (GAO) to review the early engagement of ballistic missiles to include boost and ascent phase intercepts.

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Sincerely

HENRY A. OBERING III
Lieutenant General, USAF
Director

cc:
The Honorable John P. Murtha
Ranking Member

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## B.3 (U) Letter to Chairman, Committee on Armed Services, U.S. Senate

**DEPARTMENT OF DEFENSE**
**MISSILE DEFENSE AGENCY**
**7100 DEFENSE PENTAGON**
**WASHINGTON, DC 20301-7100**

JAN 30 2006

The Honorable John W. Warner
Chairman
Committee on Armed Services
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

The House Appropriations Committee report (H.Rept.109-119) to accompany H.R. 2863, the Department of Defense Appropriations Act, 2006 directs the Secretary of Defense to conduct a joint study with the Government Accountability Office (GAO) to review the early engagement of ballistic missiles to include boost and ascent phase intercepts.

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Sincerely,

HENRY A. OBERING III
Lieutenant General, USAF
Director

cc:
The Honorable Carl Levin
Ranking Member

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## B.4 (U) Letter to Chairman, Committee on Armed Services, U.S. House of Representatives

**DEPARTMENT OF DEFENSE**
**MISSILE DEFENSE AGENCY**
**7100 DEFENSE PENTAGON**
**WASHINGTON, DC 20301-7100**

JAN 30 2006

The Honorable Duncan Hunter
Chairman
Committee on Armed Services
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

The House Appropriations Committee report (H.Rept.109-119) to accompany H.R. 2863, the Department of Defense Appropriations Act, 2006 directs the Secretary of Defense to conduct a joint study with the Government Accountability Office (GAO) to review the early engagement of ballistic missiles to include boost and ascent phase intercepts.

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Sincerely

HENRY A. OBERING III
Lieutenant General, USAF
Director

cc:
Honorable Ike Skelton
Ranking Member



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