Summary of Report to Congress on Utility of Sea-Based Assets to National Missile Defense

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Prepared By:
Ballistic Missile Defense Organization

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1. SUMMARY

1.1 PURPOSE OF THIS REPORT

In the Conference Report to accompany H.R. 1119, National Defense Authorization Act for Fiscal Year 1998, Report 105-340 (page 658), the conferees directed the Director of BMDO to submit a report "*...describing whether and how the Navy Upper Tier program could be upgraded in the future to provide a limited NMD capability. The report should address the technical issues associated with a sea-based NMD option as well as costs associated with such a concept. The report should also address whether and, if so, how a sea-based NMD system could be integrated into and supplement a ground-based NMD system, whether and, if so, how a sea-based system would provide additional capabilities in support of the requirements for the existing NMD program, and whether such a system would comply with the ABM Treaty.*"

Lt Gen Lyles submitted to Congress on 26 June 1998 a classified report, "Utility of Sea-Based Assets to National Missile Defense (U)", dated 15 May 1998 to provide the information that was requested. Subsequently, Congressional conferees requested the Secretary of Defense provide an unclassified summary of the report (House Report #105-736). This report provides the requested unclassified summary of the 15 May 1998 Report.

1.2 SCOPE OF THE REPORT

This report summarizes the results of an investigation into the potential utility of sea-based assets to NMD, an investigation that benefited from previous studies performed by BMDO and the Navy. It describes the potential utility of the Navy Theater Wide (NTW) system to the NMD mission; identifies a number of areas in which the NTW program could be upgraded to give it a significant NMD capability; identifies some potentially attractive NMD roles for sea-based elements; addresses how these sea-based roles would benefit the NMD architecture; and addresses technical issues, costs, schedules and risk.

Neither this investigation nor the studies from which it draws was as thorough as a Concept Definition Study or an Analysis of Alternatives (formerly called a Cost and Operational Effectiveness Analysis). *Thus results described herein would have to be pursued to greater depth before being used as the justification for estimating costs or proposing program changes.*

1.3 KEY ASSUMPTIONS AND CAVEATS

Since a significant part of this study was to determine if and how sea-based elements could be integrated into the land-based NMD system currently being pursued by BMDO, this study adopted the same threats and scenarios used by the land-based NMD program for threshold attack quantities. (Throughout this report, defense architectures are referred to as "land-based", or "sea-based" or both, depending upon where the interceptor missiles are based. In any of these cases, the interceptors may be supported by sensor systems located on land, at sea, or in space.) In addition, to test architecture robustness, excursions around the "baseline" threat were also performed.

The NTW system continues to undergo revision and refinements as its development proceeds. For purpose of this study, the NTW Standard Missile 3 (SM-3) (Block II) was used as the baseline for analysis, and its characteristics and capabilities as described in the NTW Draft CARD dated 29 August 1997, were used as a point of departure for system modifications and for cost comparison purposes. Subsequently, the NTW program has been described by the Navy as a two-phased development with some of the Draft CARD capabilities deferred to a Block II program. At this time, the NTW Block I program is in the process of being baselined while the NTW Block II system is being considered as a major program upgrade by the Department, and is neither completely defined, or fully funded because its development and production will occur in a timeframe largely beyond the current FYDP. (The Block I system is substantially less capable than Block II and was not analyzed for its capability against strategic ballistic missiles.) Statements made in this report about capabilities of the NTW interceptor assume these Block II capabilities have been incorporated. That is, upgrades to NTW are upgrades beyond Block II.

This study was conducted without consideration of, and without prejudice to, the terms and constraints of the Anti Ballistic Missile (ABM) Treaty. The Administration's policy is that development and testing of a fixed land-based NMD system will comply with the ABM Treaty, while deployment might require modification of the Treaty.

By necessity, the cost results presented in this report must be considered only as rough estimates. In the time available, it was not feasible to evaluate the candidate system concepts with detailed engineering analyses of the type required to support credible cost estimates. In addition, sea-based systems to a large extent would be deployed on platforms that are inherently multi-mission capable. However, in general, ship locations and load outs for NMD tend to conflict with those for theater missions. Sorting and allocating costs among the missions is a complex task beyond the scope of this study.

While this Report to Congress was in preparation, the Heritage Foundation published a report titled *Defending America, A Plan to Meet the Urgent Missile Threat*. Briefly summarized, the Heritage Report advocates a combined sea-based and space-based, global BMD architecture. The initial defense capability would be based upon the U.S. Navy's twenty-two AEGIS cruisers carrying NTW Block II interceptor missiles, supported by a constellation of low orbit Space-Based Infrared (SBIRS-Low) satellites for launch detection, target tracking and engagement control.

BMDO has conducted an initial review of the Heritage report and believes that several of the ideas expressed in the Report warrant further consideration. There are numerous differences in the assumptions and approach between the Heritage Report and this Report to Congress, particularly in regard to expected system performance, development schedules, cost estimates, and specific technical issues. However, the most important differences between the Heritage Report and this Report to Congress are driven by their different frames of reference.

The analysis contained in this Report to Congress is based on the need to meet the requirements of the JROC-approved NMD Operational Requirements Document (ORD). The ORD requires an initial NMD system able to achieve a high confidence, highly effective defense of all 50 states, against a simple, stressful, strategic ballistic missile threat. The Heritage Report focuses instead on a sea-based, global anti-missile capability, which they believe could provide the earliest protection against emergent Rest of World (ROW) ballistic missiles. The capability alone does not meet all the requirements of the NMD ORD.

Because some of the ideas contained in the Heritage Report warrant additional consideration, the BMDO will conduct additional analysis of alternatives for sea-based NMD and sea-based adjuncts to land-based NMD, to address points raised by the Heritage Report.

1.4 SUMMARY OF KEY FINDINGS

Within this context, this study produced the following fundamental conclusions about the potential utility of sea-based assets in the defense of the US:

- W*ithout upgrades, the NTW Block II system would have no useful capability against ICBMs or SLBMs. However, the unmodified NTW Block II system could have a capability against shorter range threats attacking US coastal targets.* Consistent with the theater mission for which it is intended, the NTW Block II system could have the capability to defend against tactical and intermediate range ballistic missile threats provided the NTW-capable ships are given sufficient warning of the impending attack to deploy within a few hundred kilometers of the threat launch location or of the area to be defended.
- *The NTW Block II interceptor analyzed in the NTW Analysis of Alternatives, when employed with the same sensors as planned for the land-based NMD architecture, could provide protection of the US against attacks by unsophisticated Third World threats.* Sea-based interceptor missiles require the same target identification and track accuracy as their land-based counterparts; hence they need the same sensor support. In addition, unless they are already operating in areas favorable to their participation in NMD, the sea-based assets require sufficient warning time to allow deployment to specific areas at sea. If the impending attack is from a single nation and its identity is known, then deployment in as few as three locations is required. If the adversary is unknown, or many are suspected, then as many as thirteen deployment locations may be required.
- *In order to expand this protection to include attacks by sophisticated Third World threats and accidental and unauthorized launches from existing nuclear powers, the performance of the NTW interceptor missile would*

have to be upgraded well beyond Block II, and employed with the same sensors as planned for the land-based NMD architecture. The interceptor would require significantly higher burnout velocity, better seeker performance and kill vehicle divert capability, and increased nuclear hardness. All of the required upgrades are assessed to be technically feasible.

- *The most practical and effective role for sea-based systems would be to supplement land-based systems.* An integrated (combined land and sea) NMD architecture could provide more operational flexibility and robustness than architectures that relied solely on sea-based interceptors or on a single land-based interceptor site. However, deployment of such a land-plus-sea-based architecture is not feasible within the land-based NMD schedule and would require additional RDT&E and procurement funding. An NMD architecture integrating sea-based interceptors with NMD sensors and land-based interceptors could provide enhanced protection of the US by reducing the vulnerability of forward land-based radars to defense suppression attacks; providing higher total kill probability by adding additional, earlier engagement opportunities; and reducing the impact of potential single-system failures. It could also provide the flexibility to reconfigure the defensive deployment in response to particular threats, and could provide a hedge against unanticipated threat tactics such as severely depressed trajectories. This integrated architecture could also give the defense planner an alternative to multiple land-based sites as a means to reduce the interceptor flyout velocity, and hence the technical and engineering risk to the NMD development program. The addition of the mobile sea-based launch platforms could also offer the possibility of extending the NMD mission to include defense of US territories, and defense against ship-launched ballistic missiles. For some of these roles, upgrades beyond the NTW Block II interceptor would be required; for others, the Block II interceptor envisioned by the Draft CARD dated 29 August 1997 would suffice.

- *Deployment of a partial sea-based NMD capability while feasible, has technical risks and engineering challenges that have not yet been proven or demonstrated. In addition, the program is constrained by funding and programmatic factors.* While the evolutionary acquisition strategy that will lead to the NTW Block II system is approved, the Block II system is not completely defined or fully funded because its development and production will occur in a time frame largely beyond the current FYDP. Funds exist in the current FYDP for a portion of Block II Risk Reduction Activities as part of the Block I program. To achieve the most expeditious sea-based NMD capability, the NTW Block II must be completely defined and additional funds programmed. *Given these 2 conditions, it could be reasonably expected that the deployment of Block II could begin within 4 years after the Block I first-unit-equipped (FUE) date.*

- The cost and technical risk associated with the introduction and sustainment of sea-based assets into the NMD BM/C3 architecture is a matter of uncertainty that cannot be reduced without detailed engineering analysis of the most promising integrated architectures. While such architectures are technically feasible and operationally practical, their affordability and their cost effectiveness relative to multiple-site land-based architectures are yet to be determined.

- The post-FY97 RDT&E procurement and military construction for the land-based NMD Capability 2 architecture (with 80 to 100 interceptors based in Alaska) is estimated to cost between $13B to $14B. *Alternatively, a stand-alone sea-based architecture that could protect all 50 states is estimated to cost $16B to $19B* (rough order of magnitude estimate that includes the cost of 3-6 AEGIS–type ships). All costs prior FY97 are sunk and were not included. Furthermore, the estimates assume that the NTW Block II program and design are available without cost to the NMD Program (NTW Blk II RDT&E, procurement & O&S costs not included in ROM estimate). The stand-alone, sea-based architecture would require the same sensor suite, BM/C3 system and exo-atmospheric kill vehicle (EKV) currently under development in the land-based NMD program. At the same time, the stand-alone sea-based architecture would be comprised of dedicated ships and to account for ship rotation, significantly more sea-based interceptors than the 80-100 planned for the land-based NMD architecture.

The use of NTW in support of an NMD system would raise significant ABM Treaty issues. The DoD has not assessed the compliance of such use. The DoD assess the compliance of approved and sufficiently defined programs. However, the architectures and approaches discussed in this report are not under consideration for approval as a program by the DoD, and have not been submitted for compliance review.

2. NMD STUDY CONTEXT

2.1 INTRODUCTION

This section provides a brief overview of the current NMD mission and the BMDO program that addresses that mission. It is intended to provide a context for the discussion of the potential utility of sea-based assets for NMD.

2.2 NMD MISSION

The NMD mission is to protect the US from limited ballistic missile attacks from rogue nations. The system will also provide some capability against accidental and unauthorized launches. Because the mission is the defense of the homeland against weapons of mass destruction, the requirements levied on the defensive system are stringent. At the Threshold level, the defensive system is required to protect all fifty states from an authorized attack by unsophisticated warheads. At the Objective level, the desired protection is against advanced rogue or unauthorized and accidental attacks by sophisticated warheads.

These NMD performance requirements are more demanding than any for the US theater ballistic missile defense (TBMD) systems, and the penetration aids projected for NMD threats are also more stressing than for TBMD threats. Also in contrast with TBMD missions, the NMD mission requires a huge footprint of coverage to defend all fifty states from wherever the threat may arise. In addition, the defense must maintain a high state of readiness to respond to unanticipated attacks, and must be prepared to function in a hostile environment.

2.3 NMD PROGRAM

To meet the Capstone Requirements Document (CRD) requirements, the NMD Joint Project Office (JPO) at BMDO has created a program to develop a defensive system that will evolve through three levels of capability:

- Capability 1 satisfies CRD Threshold requirements: The system provides the required performance against an unsophisticated rogue-state threat at the Threshold level. The Administration and the Congress want the option of fielding this capability by the year 2003 given a deployment decision in 2000.
- Capability 2: The system provides the required performance against any authorized, unauthorized, or accidental attack by sophisticated or unsophisticated payloads at the Threshold level.
- Capability 3 satisfies the CRD Objective: The system provides the required performance against any authorized, unauthorized, or accidental attack by sophisticated payloads at the Objective level.

2.4 NMD ARCHITECTURE AND CONCEPT OF OPERATION

The NMD program seeks to develop an architecture that can protect the entire US with interceptors based either at a single ground site or multiple sites depending on the emergence of the threat. An obvious candidate for the single site is Grand Forks, ND, which is allowed by the ABM Treaty. This and other locations, as well as multiple sites, are under consideration.

To achieve maximum capability, the NMD architecture will rely on an extensive array of sensors to provide accurate threat warning, tracking and discrimination as early in the threat trajectory as possible. The architecture will employ space-based infrared sensors of the Defense Support Program (DSP) and its eventual successor, the Space-Based Infrared System in geosynchronous and elliptical orbits (SBIRS-High) for attack warning and for cueing other sensors. Since the high performance requirements demand redundancy in almost every function, attack warning and cueing will also be provided by upgraded Early Warning Radars (UEWRs). The Air Force is currently designing a low earth orbit constellation of infrared sensor platforms (SBIRS-Low) for missile tracking. When it is available, SBIRS-Low will provide tracking and midcourse discrimination data to the BM/C3 system. X-band radars may be needed for tracking, discrimination and endgame support for the Capability 2 architecture. SBIRS-Low will not be available for the earliest schedule options for Capability 1.

The Ground Based Interceptor (GBI) will have an acceleration profile and burnout velocity that maximize the interceptor's reach, consistent with the long-range capability of the supporting sensors. The GBI payload will be an Exo-Atmospheric Kill Vehicle (EKV) equipped with a high-sensitivity infrared seeker and an agile divert system to support endgame intercepts of responsive threats at very high closing velocities. In addition, the payload will be hardened to elevated doses of X-rays to allow operation in nuclear environments. To limit the adverse effects of this environment on the interceptor, the defense battle management will distribute the engagements within the available battlespace; the larger the battlespace, the wider the separation, and the weaker the deleterious effects of a nuclear environment.

The BM/C3 system will provide in-flight target updates (IFTUs) to the interceptors, and in complicated situations, target object maps (TOMs) that distinguish the warhead from decoys and midcourse debris. The IFTUs and TOMs will be sent from the ground to the interceptors via a distributed and redundant In-Flight Interceptor Communication Subsystem (IFICS), designed to assure communication under all natural climate conditions and in all hostile environments. Also, to achieve high confidence of success against all threat objects, salvos of interceptors may be launched against each credible threat object. These salvos will be spaced in time to reduce the likelihood of correlated errors among the intercept attempts.

3. SEA-BASED ELEMENTS FOR NMD ARCHITECTURES

Several architecture options become possible when sea-based elements are added in some combination to land-based elements, either sensors or interceptors or both. The major variations of the sea-based elements used in the study are as follows:

Sensor Suites (in addition to DSP or SBIRS-High):

- Sea-based radars (collocated with interceptors, and remote)
  - Upgraded shipboard radar
  - New X-Band radars
- NMD Capability 1 Sensor Suite (Upgraded Early Warning Radars [UEWR] and Forward X-Band Radars)
- NMD Capability 2 Sensor Suite (Capability 1 Sensor Suite plus SBIRS-Low with UEWR optional contingent on C1 deployment decision)

Interceptors:

- Burnout Velocity, V_{BO}
- Kill Vehicle Sensor Performance: Ranging from LEAP upgrades to a maritime EKV
- Kill Vehicle Hardness to nuclear weapon effects

BM/C3:

- Centralized battle planning, distributed execution
- Communication uplink to sea-based interceptors; from AEGIS platforms or via land-based in-flight interceptor communication system (IFICS)

The remainder of this section presents a brief description of the NTW Block II system and its potential derivatives, and Section 4 presents an assessment of the architecture options formed from these elements. All the NTW upgrades included in the discussion have been assessed as technically feasible within the current state of the art, although some represent significant departures from both the current NTW program and the NTW Block II system.

3.1 NTW PROGRAM BASELINE

The Navy Theater Ballistic Missile Defense (TBMD) Program is based on the existing AEGIS Combat System (ACS) which was developed for and deployed on 27 Navy cruisers and more than 30 guided missile destroyers. The first AEGIS TBMD mission capability will be the Navy Area system, often referred to as the Navy Lower Tier system. The Navy Area Program involves modifications to the integrated equipment and computer programs which comprise the AEGIS Weapon System (AWS) to enable detection and engagement of theater ballistic missiles in the endoatmosphere and control of the interceptor designed to kill the threat missile. It is an evolutionary program which continues the development of the STANDARD family of guided missiles, begun more than thirty years ago.

The Navy Theater Wide (NTW) Program will continue this evolutionary process to enable the ACS to defend a larger area against long range TBM threats and at greater range. The NTW Program is currently in the Program Definition and Risk Reduction Phase of development. The Navy intends to propose the two-phase approach illustrated in Figure 3-1. The first phase, Block I, will address the current preponderant TBMD threat. NTW Block II will be treated as a major acquisition upgrade to the Block I Program. For the purpose of this study, the NTW Standard Missile-3 (SM-3) (Block II) was used as the baseline for analysis, and its characteristics and capabilities as described in the NTW Draft CARD dated 29 August 1997 were used as a point of departure for system modifications and for cost comparison purposes.

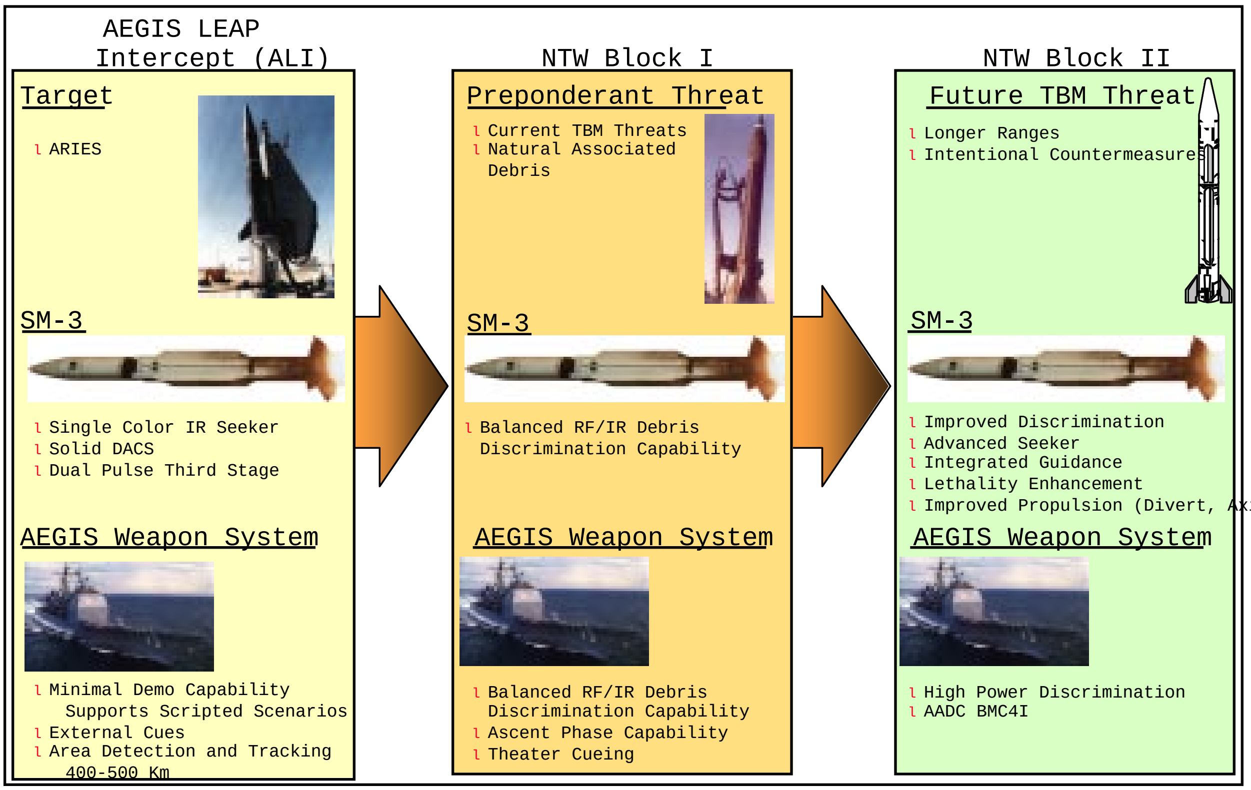

Figure 3-1. NTW TBMD Evolutionary Approach

The Navy and BMDO are exploring funding sources above the currently approved budget to accelerate development and deployment of the initial NTW Block I. The Block II NTW system is not completely defined or fully funded. In order for a partial sea-based NMD capability to be achieved expeditiously, the NTW Block II program must be planned, funded and executed in order to achieve a FUE date within four years of the FUE for Block I. *Deployment of a Block II NTW-based system would be well beyond the current timeline for the land-based NMD Capability 1 architecture.*

3.2 POTENTIAL NMD ROLES FOR NTW BLOCK II SYSTEM AND ITS DERIVATIVES

Elements of the NTW Block II system or its derivatives could be used for NMD in a variety of ways. The major options are:

- Sea-based interceptors used with or without support from external sensors (other sea, land, and space-based sensors) to provide total ballistic missile defense of the US;
- Sea-based interceptors integrated with land-based interceptors and used with external sensors to augment the land-based NMD by providing enhanced robustness and/or reduced risk;
- Sea-based interceptors integrated with land-based interceptors and external sensors, as above, to provide an expanded defense capability of the US beyond that currently planned for the NMD program. The expanded mission may include protection of the US against a more robust threat, and/or protection of US territories and possessions as well as the fifty states.

The strategic ballistic missile threats to the US have different characteristics than the ballistic missiles that threaten overseas theaters of operation. NMD threat missiles are faster; cooler due to payload separation and an extended exoatmospheric flight; and may incorporate sophisticated penetration aids. The differences render theater ballistic missile defense (TBMD) systems inappropriate for use in NMD. Even TBMD systems such as NTW Block II that are designed to defeat long-range theater threats would have no practical utility without significant modifications or upgrades. While the extent of these modifications depends on the particular role envisioned for the sea-based systems, the general nature of the changes involve the key system functions: detection and tracking; control and engagement; interceptor flyout velocity; system discrimination; kill vehicle tracking and divert; and nuclear effects hardening. The most significant of these are described below.

3.2.1 NTW Detection And Tracking

The ability of the warning and tracking system to provide early, over-the-horizon information to the interceptor will determine how much of the kinematic footprint the interceptor can use for defense engagement. The AEGIS AN/SPY-1B radar is not capable of supporting NMD type engagements due to limited detection and tracking ranges for strategic (long range) ballistic missiles and their reentry vehicles. If supported by a more capable sensor (and if other upgrades to fire control, processing and communications are made), the NTW Block II interceptor would have a limited capability against some NMD threats. A more powerful radar, to enhance detection and tracking, could be incorporated into the AEGIS platform; provided on another afloat platform; or provided by the currently planned, NMD land-based sensors. When available, the infrared sensors on SBIRS-Low could perform the same function.

3.2.2 NTW Interceptor Velocity

The interceptor burnout velocity determines the maximum kinematic area that can be defended by an interceptor and therefore the minimum number of launch areas (i.e., ship operating areas) required to protect the US. Hence increasing the burn-out velocity (V_{BO}) beyond that of the NTW Block II interceptor is a key consideration for achieving enhanced performance in an NMD role. [Note, the NTW Block II would have a significantly higher V_{bo} than Block I.] Options to increase the burn-out velocity include the introduction of new propulsion technology and/or the replacement of the boost stages of the NTW II interceptor with larger, more capable stages. The former is limited by the level of risk deemed appropriate for such a program. The latter includes options for a larger diameter Vertical Launch System (VLS) tube and extension of the tube above the deck. However, within these limits there is room for substantial improvement in interceptor burn-out velocity to levels required for the NMD mission. These more capable interceptors could be deployed on AEGIS ships or on other sea-going platforms equipped with a communication system linking the platform to the BM/C3 system.

3.2.3 NTW Tracking And Divert

This study addressed two different kill vehicle options. Each has different capabilities which affect the end-game target acquisition and capacity to divert for aimpoint selection and kill. The NTW Block II interceptor features a LEAP kill vehicle. Although LEAP appears to have sufficient divert capability to support engagement of unsophisticated NMD threats, it would require improvement of the infrared sensor to acquire cooler, more advanced NMD threats. Engaging the most difficult threats would require kill vehicle capabilities similar to those found in the EKV now being developed for the land-based NMD system.

3.2.4 Kill Vehicle Hardening

The nuclear warheads onboard ICBMs and SLBMs raise the possibility that defensive interceptors may be required to perform their mission in a nuclear environment. This would occur if the attacker launched more than one nuclear warhead at the same target to arrive about the same time, <u>and</u> if the threat warheads were armed to detonate if impacted by defensive kill vehicles ("salvage fusing"). In this case, a successful intercept of the first threat warhead would produce a nuclear detonation through which a second kill vehicle must fly as it attempts to intercept the second threat warhead. If the kill vehicle is not hardened for such an environment, its seeker and guidance and control systems would cease to operate, thereby preventing a successful intercept.

This hardening requirement is driven by the nuclear yield of the threat warhead, the attack laydown, and the available defense battlespace. For the NMD scenarios currently envisioned, the value of this requirement is beyond the capability of the LEAP kill vehicle currently envisioned for the NTW Block II interceptor. Only the EKV under development for the land-based NMD system is designed with sufficient nuclear hardening to meet this requirement against the spectrum of these scenarios.

3.2.5 BM/C3 And Integration Considerations

In addition to interceptor and sensor modifications and replacements, effective use of sea-based elements in NMD would require modification of the NMD concept of operation and integration with the NMD BM/C3 architecture. Sea-based interceptor platforms would be intrinsically mobile and highly dispersed, and they would offer the opportunity to engage the threat early in its trajectory, possibly as early as in its ascent phase. This would provide an additional defense layer that could engage the threat ahead of the land-based interceptors, and thus provide a multi-tiered defense architecture that has the potential for more robust and more confident protection.

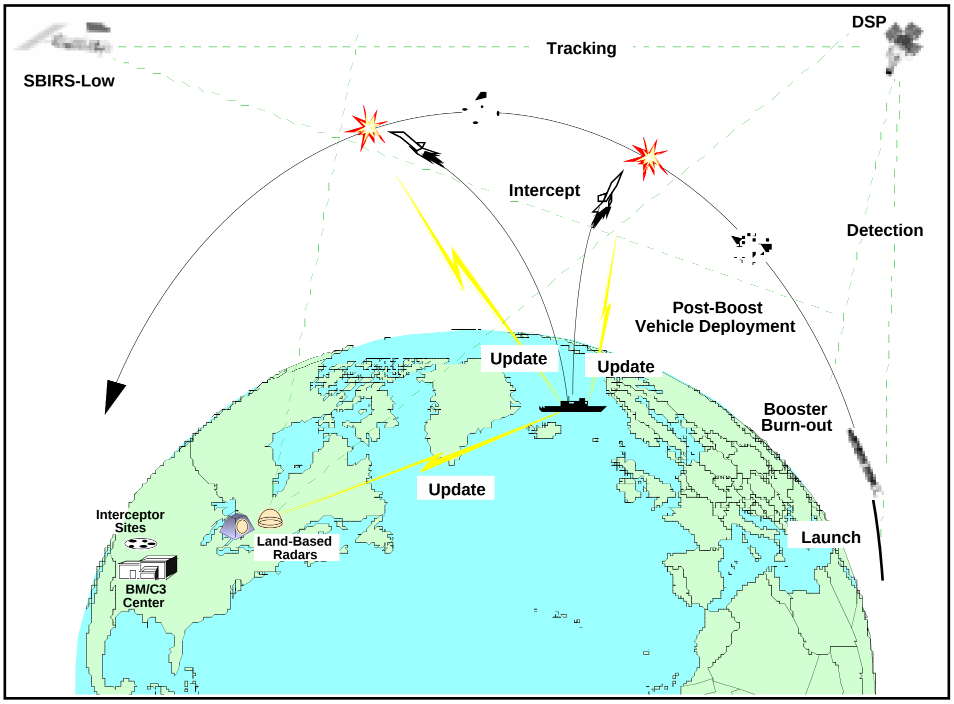

Figure 3-3. Illustrative AEGIS Cruiser NMD Engagement

To realize this potential, the NMD BM/C3 architecture would have to be modified to provide full connectivity to the sea-based assets. Command and control would have to be capable of repositioning interceptor launch platforms to maximize battlespace and to resolve conflicts that inevitably arise with multi-mission, sea-based assets. Response timelines would have to be shortened to accommodate the more stressing ascent phase engagements. Firing logic would have to be modified to provide unambiguous weapon target assignments among and within the sea-based and land-based interceptor sites. To the extent that kill assessment techniques become reliable, real-time firing strategies could include shoot-look-shoot opportunities as well as salvo interceptor launches.

In addition, shipboard BM/C3 changes would also be required. AEGIS ship C3 suites would have to be modified to enhance global command interfaces. This includes long-range and satellite communications, rapid intelligence and target data processing, and direct downlinks from planned space assets to accelerate the warning-alert-rapid-response sequence. Modifications to AEGIS Weapons System software would be required to process NMD mission data and to support decentralized decision-making. This includes changes to software logic to collect, manipulate, and display strategic-class threat information in real-time scenarios on the AEGIS Display System. Software logic changes are also needed within AEGIS Command & Decision (C&D) components for threat prioritization and processing of the ranges, altitudes, and broad battlespace which are inherent to strategic scenarios. Finally, modifications to AEGIS Weapons Control System hardware would be required to ensure missile launch readiness and positive command of the missile in flight over extended ranges.

4. ARCHITECTURE ASSESSMENTS

Architectures based in whole or in part on the NTW system and its potential derivatives were evaluated in the context of the threats being addressed by the BMDO land-based NMD program. Sensitivities of architecture performance to changes in threat trajectories (reentry angle), payload sophistication (penetration aids), targeted aimpoints and precursor defense-suppression attacks were considered.

The architecture options ranged from stand-alone sea-based assets (both unmodified and modified NTW Block II system elements) to combinations of sea-based and land-based interceptors with appropriate land-, sea- and/or space-based sensors. Sea-based elements were located in regions where their contribution to the defense of the US was greatest, subject to year-round accessibility (i.e., icepack) constraints and obvious undesirable proximity to attacking nations. Otherwise, the sea-based assets were not constrained to the normal operating areas dictated by their other missions.

A summary of the architecture options and their potential utility is shown in Table 4-1. A more detailed discussion of their attributes and limitations is provided in the remainder of Section 4.

Table 4-1. Sea-Based And Sea-Plus-Land-Based NMD Options

Interceptors			
Sea Based	**Land Based**	**Sensors**	**NMD Utility Against Limited Attacks**
NTW Blk II	None	Current Shipboard Radar	• None Against ICBMs, SLBMs • Defend Coastal Cities Against Threats of TBM to intermediate range
NTW Blk II	None	NMD Sensors*	• Defend US Against Unsophisticated ICBM, SLBM Attack By ROW
NTW Blk II	GBI	NMD Sensors*	• Defend US Against Sophisticated Ballistic Missiles
Upgrade Beyond NTW Blk II	None	NMD Sensors* With SBIRS-Low	• Defend US Against Sophisticated Ballistic Missiles
Upgraded Beyond NTW BLK II	GBI	NMD Sensors* With, SBIRS-Low	• Defend US Against Sophisticated Ballistic Missiles
*NMD Sensor: Upgraded Early Warning Radars, Forward-Based Radars and/or SBIRS-Low			

4.1 UNMODIFIED NTW SYSTEM

Without upgrades, the NTW Block II system has no useful capability against ICBMs or SLBMs. However, the unmodified NTW Block II system does have a capability against shorter range threats attacking US coastal targets. It can defend against tactical and intermediate range ballistic missile provided the NTW-capable ships are given sufficient warning of the impending attack to deploy within a few hundred kilometers of the threat launch or target location. The NTW Block II system can provide such protection against the kinds of nuclear weapons projected to be available to Third World nations.

4.2 NTW Block II Interceptor Supported By External Sensors

For defense against ICBMs and SLBMs, the NMD architecture needs sensors that can provide commit-quality tracking of threats long before impact. The earlier the detection and tracking functions are accomplished, the fewer the interceptors and launch sites that are needed for protection of the US. In the land-based baseline NMD architecture, these functions are provided by upgraded early warning radars and forward-based radars and also by SBIRS-Low when it becomes available. SBIRS-Low will provide continuous, nearly world-wide coverage. It will extend viewing well beyond radar horizons, particularly against threats launched from the Eurasian land-mass.

Properly deployed ship-based radars with ranges of about 2000 km can provide a forward-based radar commit function against many of the potential threats to the US. These radars can remain silent until cued by DSP or SBIRS-High. Because they would be difficult to target due to mobility and unknown location of ships, they would add robustness against defense suppression attacks, particularly before SBIRS-Low is available.

Interceptor coverage and efficiency are enhanced for NMD if interceptor launch platforms are located downrange of these commit sensor platforms near the points where intercepts will occur (provided of course that the information is passed promptly among these sensor and shooter platforms). Thus, it may be more efficient and effective to employ radars on ship platforms of opportunity rather than to upgrade AN/SPY-1 radars for this purpose.

If suitable external sensors are employed, the NTW Block II interceptor would become capable of using early commit-quality tracks of ICBM and SLBM boosters and reentry vehicles. In this modified configuration, an NMD system based on the NTW Block II interceptor could protect the US against attacks from N. Korea and other “Rest of World” (ROW) threats. Depending on the attacking country and details of the attack scenario, modified ships may be needed in as few as 3 different locations at sea to provide this protection, or in as many as 13 locations to provide protection against all of these countries simultaneously. It should be noted that many of these ship locations are incompatible with operating areas for AEGIS ships supporting the TBMD mission and other theater missions (e.g., Tomahawk strike, anti-air warfare).

The ability of this configuration to protect against nuclear warheads targeted in-line at the same aimpoint is limited by the nuclear yield of the threat warheads and the intrinsic nuclear hardness of the kill vehicle. This system with NTW Block II interceptors can protect against several contact- or salvage-fused nuclear warheads of a yield typical of Third World nations.

The level of protection and the number of ships required to achieve it can be improved significantly by increasing the nuclear hardness of the NTW Block II kill vehicle. For example, if the nuclear hardness is increased to approach the level being designed into the EKV, then this interceptor and sensor architecture acting alone could protect against an attack of several unsophisticated, in-line reentry vehicles from most potential launch points. Moreover, assuming its burnout velocity is not substantially lowered by shielding weight to obtain this hardness, ships would be needed at only five locations for the ROW threats only, or at only seven locations to protect the US from the PRC as well.

Whether the kill vehicle is hardened or not, the NTW Block II system, even integrated with the land-based NMD sensor and BM/C3 architecture, cannot provide reliable protection against accidental or unauthorized launches from all nuclear states. With a large number of ship locations and the hardness upgrade, the NTW Block II interceptor integrated with NMD sensors and BM/C3 could provide protection against an attack on CONUS, Hawaii and portions of Alaska by a few reentry vehicles. However, the system does not have a high enough burn-out velocity to confidently protect all of Alaska.

4.3 NTW BLOCK II SYSTEM INTEGRATED INTO THE LAND-BASED NMD SYSTEM

The NTW Block II, as part of an integrated sea- and land--based NMD architecture with space-based sensor support, could provide protection to the US that is far superior to that which can be provided by the NTW system alone (with or without external sensors), or by the single-site, land-based architecture alone (with or without space-based sensors). Specifically, this fully integrated architecture could add robustness, reduce program risk, expand protection to US Territories, and contribute to defense against ship-based ballistic missile threats to the US.

In many cases, sea-based systems are not unique in providing these benefits. That is, the same or similar benefits can be available by adding one or more land-based sites. The major exception to this stems from the intrinsic mobility of the sea-based interceptor platforms. This allows the defense to tailor the architecture to the specific threat at hand, while adding substantial uncertainty to a potential attacker's planning and expectation of achieving his attack objectives. The principal benefits of the integrated architecture are discussed below.

Robustness Benefits.

Defense of the US (from Miami, Florida to Alaska's Aleutian Islands, and from Bangor, Maine to the Hawaiian Islands) against launches from N. Korea, other ROW threats, PRC, and Russia, from a single-site deployment is challenging. In addition, defense coverage and effectiveness are sensitive to assumptions about the threat characteristics and tactics. Incorporation of the modified NTW Block II system can mitigate, and in some cases, totally remove these vulnerabilities and uncertainties.

For example, adding modified NTW Block II ships to the architecture would provide increased protection against a pre-emptive attack on the land-based NMD assets. In addition, because it would also increase the battlespace of the overall NMD architecture, addition of the modified NTW Block II ships would protect against a broader range of countermeasures, for example, depressed trajectories lower than currently predicted by the intelligence community. The larger battlespace would also allow engagements much earlier in the threat trajectory, thereby accommodating shoot-look-shoot strategies and mitigating the impact of correlated failures within the defensive system. Finally, if there is strategic warning of an attack, a modified NTW Block II ship could be positioned along the anticipated threat trajectory, thereby increasing the number of shot opportunities and hence the confidence of kill.

Reduced Program Risk.

In addition to the above performance benefits and reduced susceptibilities to threat and phenomenology uncertainties, other significant benefits could accrue to NMD:

- If the defense could deploy one or two ships to expand the battlespace, the GBI could be slower, and the GBI seeker design details would no longer be as critical. Reduced NMD program risk would result either by redesigning the interceptor to make the overall configuration easier to build, or retaining the designs and having substantial design margin.
- As noted earlier, many of the same benefits could be achieved by deploying more than one ground-based site. However, there is a difference in these alternatives when considering the cost and schedule risks attendant with the Environmental Impact Statement process.

Mission and Threat Growth

The NTW Block II system integrated with NMD sensors and/or ship-based radars could also contribute in other areas of potential importance. For example, should future geo-strategic events require it, missile defense could be provided beyond the borders of the United States, to include US territories, by the addition of more NTW-capable ships. Similarly, certain sea-launched threats could be more effectively countered by adding NTW-capable ships. Finally, integration with SBIRS-Low could enhance the NTW Block II capability to protect US Allies.

4.4 NTW Block II System With Major Upgrades

Major upgrades to the interceptor and kill vehicle (KV) well beyond NTW Block II would be required if sea-based interceptors are to contribute significantly toward defeating sophisticated threats. The interceptor burnout velocity must be increased, and the KV must be upgraded. With these upgrades it would be technically feasible to have sea-based defenses conduct the full Capability 1 and Capability 2 NMD Missions.

4.4.1 Stand-Alone Sea-Based Architecture

A stand-alone capability against the C1 threats requires support by the Capability 1 sensor architecture and an interceptor with a burn-out velocity significantly greater than that of the NTW Block II system. The level of sophistication of the countermeasures that could be defeated but such an architecture would depend on the type of kill vehicle deployed on this faster interceptor (upgraded LEAP or EKV). However, in any case without SBIRS-Low, portions of Alaska could not be confidently protected in all scenarios.

This architecture would require only a few ships at sea. Moreover, depending on the actual interceptor burn-out velocity, the operating regions for these ships could be very broad.

4.4.2 Integrated Sea-Based And Land-Based Architecture

Integrated with land-based NMD, a sea-based interceptor with high burn-out velocity would allow other options to be considered. For example, land-based GBI could be deployed at Grand Forks, while the Navy protects Alaska and Hawaii to the level required. However, the solution would be threat dependent. If the threat to Alaska becomes North Korea, NTW Block II interceptor would be sufficient. These might be surged for only as long as needed (no long-term dedication to the mission). If the threat to Alaska is an accidental or unauthorized launch from Russia, a faster, hardened interceptor would be needed, and long-term dedication may be required if the threat persists.

The land-based and sea-based interceptors could be designed as a common interceptor. This may offer some programmatic benefits. With the EKV common to both, it would be effective against the NMD Capability 2 threats. (However, there is also merit in not having all KVs identical in order to prevent the possibility of a blanket countermeasure by an enemy and to prevent a technical problem from affecting 100% of the defense.) With a burnout velocity substantially greater than the NTW Block II interceptor, the common interceptor would allow CONUS-wide protection from a site at Grand Forks. The rest of the US would be protected by the sea-based interceptors.

Interceptor burnout velocities beyond Block II do not appear important for protection of US Territories. Against potential ship-launched ballistic missile threats, the extra burnout velocity would allow engagements at greater standoff range. However, perhaps only a relatively small portion of the AEGIS VLS ships would be outfitted with these higher velocity interceptors. If it is known which ships pose such a threat, there would be no need to standoff at great range.

4.5 COST, SCHEDULE AND RISK

In this section, we examine the costs, schedules, and risks of architectures in which sea-based elements:

- support the NMD land-based architecture against ROW threats. These architectures would require little or no change to the NTW interceptor, but they would require integration of these interceptors and their fire control system with NMD BM/C3 and sensors. They may require very capable sea-based radars.

- are upgraded to be capable against advanced NMD threats. These architectures would require sea-based interceptors with much higher burnout velocity than the NTW Block II, and with kill vehicle capabilities and nuclear hardness comparable to the EKV. They also would require integration of the sea-based interceptors with NMD BM/C3 and sensors. To fully replace land-based interceptors, sea-based elements would have to be on station at all times if it were required to protect against accidental or unauthorized launches.
- are fully integrated with the land-based interceptor architecture. We address here a common interceptor for land and sea-basing, and compare its architecture cost with land-basing only.

The cost estimates assume the NTW Block II program and design, as described in the NTW Draft CARD dated 29 August 1997, are available without cost to the NMD program, and costs for the NMD program through FY-97 are sunk costs and not included. Costs are in constant FY97 dollars. In general, costs are expressed as a range to address uncertainties. For example, the cost of ships and NTW interceptors (procurement and/or O&S) may be considered as available at no cost to NMD or may result in an additional cost to NMD.

By necessity, the cost results presented in this report are only rough estimates. In the time available, it was not feasible to evaluate the candidate system concepts with detailed engineering analyses of the type required to support credible cost estimates. In addition, sea-based systems to a large extent would be deployed on platforms that are inherently multi-mission capable. Sorting and allocating costs among the missions is a complex task beyond the scope of this study.

As a result, the reader should keep in mind that this report cites two very different cost estimates. The first are those for a land-based NMD architecture that is relatively mature (Cost Analysis Improvement Group-approved estimates based upon detailed analysis of the architecture and its development program). The second are rough estimates of sea-based components generated from two months of top-level analysis and based to a large degree on analogies with other systems. All cost figures associated with the sea-based portion of NMD are rough order of magnitude (ROM) estimates and are so designated in the following paragraphs.

The cost associated with the introduction and sustainment of sea-based assets into the NMD architecture is a matter of considerable uncertainty and importance. For reasons cited earlier, reliable cost estimates are not yet available, and they cannot be obtained without detailed engineering analysis of the most promising integrated architectures. *Such architectures are technically feasible and operationally practical, but their affordability and their cost effectiveness relative to multiple-site land-based architectures are yet to be determined.*

4.5.1 Augmenting the Land-Based Architecture Against ROW Threats

We found areas in which the land-based architecture could be made more robust, the development could be made with lower risk, or mission capability could be extended. These architecture benefits would be available at relatively low cost for development and procurement, because for these missions, the NTW Block II interceptor would suffice, and only a few AEGIS ships would be required. For example,

- Sea-based radars could be added to the NMD architecture to provide robustness against certain defense suppression attacks before SBIRS-Low is available, and in some scenarios, to provide an earlier interceptor commit. Two such radars could be procured, installed on existing ships, and integrated with NMD BM/C3 for a total cost of less than $0.5B (ROM). O&S costs for the ships would total about $0.03B/year (ROM).
- NTW system could be upgraded to allow its unmodified Block II interceptors to be launched against ICBM-class threats based on external data provided from the NMD BM/C3. RDT&E for necessary software upgrades and testing is estimated to require less than $0.5B (ROM). The subsequent cost to equip the fleet to be interoperable with NMD BM/C3 has not been estimated, but is not expected to be very significant. Ships in small numbers, if so modified, could expand the battlespace of the architecture thereby making it more robust to countermeasures, and could extend protection to US territories from ROW threats.

4.5.2 Stand-Alone Architectures With Sea-Based Interceptors

NMD architectures require the same sensor support and BM/C3 system regardless of whether the interceptors are based on land or at sea. In addition, in either case the interceptors would need EKV-like kill vehicles to defeat sophisticated threats. Performing the entire NMD mission using sea-based interceptors would require dedicated ships to ensure adequate performance when there is no strategic warning (e.g., accidental launch). The major differences, then, between sea-based and land-based architectures would be in the number, size and launch tubes for the interceptors; the uplink to the interceptors; and the facilities supporting the launch crews.

The cost for the land-based NMD Capability 2 architecture with 80 to 100 interceptors based in Alaska is about $13B to $14B for the post-FY97 RDT&E, procurement and military construction. The cost for the stand-alone sea-based architecture to protect all 50 states is estimated to be $16B to $19B (ROM) (includes estimated $700M for NTW Block II RDT&E). In both cases, more than $8B (ROM) is associated with sensors and BM/C3, while the EKV is a major portion of the estimated interceptor costs. For the sea-based architecture case, lower military construction costs would be offset by higher interceptor development and procurement costs, since this case would require a new interceptor not now under development, and it would require many more interceptors than are needed for the land-based case. In addition, the sea-based case would require dedicated launch platforms. These may be as simple as platforms equipped with the vertical launch system and the appropriate communications system, or as complex as full-up AEGIS ships. The afore stated estimate includes the cost of 3 to 6 AEGIS-type ships as a rough estimate of the ship acquisition costs. The sea-based architecture case could also add $0.1B per year (ROM) to O&S.

4.5.3 Integrated Land And Sea-Based Architectures For NMD Capability 2

If the NMD architecture could rely on ship-based interceptors as part of the NMD solution, the land-based interceptor could be scaled back. Its burnout velocity could be reduced and still be capable of CONUS-wide defense from a site near Grand Forks. If threat circumstances warranted, sea-based interceptors with EKV and an enhanced burnout velocity could protect Alaska and Hawaii from a limited attack from all launch sites under consideration.

In fact, land-based and sea-based interceptors could share a common design. The land-based interceptor at Grand Forks and the sea-based interceptor south of Alaska could together protect all 50 states. It should be noted that protection of Alaska and Hawaii could alternatively be provided by adding a land-based site in Alaska instead of basing it at sea. Thus, this common interceptor would be adaptable to any situation that allows multiple sites for the interceptor.

The acquisition cost of an integrated architecture for NMD that has a common burnout velocity interceptor for land and sea basing, and is capable of protecting against Capability 2 threats is estimated to be $14 to $17B (ROM). Uncertainties in this estimate include the potential need for extra testing for land and sea applications, the potential need for a Program Definition, Risk Reduction phase of up to $1B (ROM), and whether procurement and O&S costs for ships should be included.

Alternatively, if this interceptor is developed but is based only on land (Grand Forks and Alaska), the acquisition cost is estimated to be $14 to $15B (ROM) (assuming the decision is made early enough to avoid the costs of sea-based platforms and tests). A major uncertainty in the RDT&E costs is in the potential need for a PDRR phase for development of the interceptor.

4.5.4 Schedule

The analysis presented in this report assumes as its starting point the existence of the NTW interceptor described in the 29 August 1997 NTW CARD. This is essentially equivalent to the Block II system in the recently revised program plan. The current NTW program is structured around the Block I system, a substantially less capable system. Deployment of a partial sea-based NMD capability while feasible, has technical risks and engineering challenges that have not yet been proven or demonstrated. In addition, the program is constrained by funding and programmatic factors. The Navy and BMDO are exploring funding sources above the currently approved budget to accelerate development and deployment of the initial NTW Block I capability. The NTW Block II system is not currently budgeted for or approved. In order for a partial sea-based NMD capability to be achieved expeditiously, the NTW Block II program must be planned, funded and executed in order to achieve a first-unit-equipped (FUE) date within four years of the FUE for Block I. In addition, sufficient funding must be made available for NTW BM/C3 integration into the land-based NMD architecture.

4.5.5 Risk

None of the modifications to the NTW system discussed in this report have been subjected to detailed trade-off analysis or design studies. Until such technical work is completed, the technical, schedule and cost risks associated with proceeding down a path that includes any of these options would be substantially greater than those associated with a land-based architecture. As noted, above, the NTW interceptor currently under development is the Block I system, a substantially less capable interceptor than the Block II system represented in the 29 August 1997 CARD. While there is little doubt the Block II interceptor, or an upgrade with higher velocity, can be built, a significant engineering effort would be required to ensure effective integration of such a missile into the maritime environment, and into the vertical launch system.

In addition, all the options discussed in this report require the integration of the on-board AEGIS fire control system into the NMD BM/C3 architecture. While technically feasible, this will invariably introduce increased complexity into the overall system. The AEGIS Combat System controls all the ship's weapon systems, including those for air defense, cruise missile defense, surface offense and defense, and Undersea Warfare (USW). The NMD requirements must be added to this system without compromising the functionality and effectiveness of the command and control system.

5. ABM TREATY CONSIDERATIONS

The purpose of the 1972 ABM Treaty (ABMT) is to limit anti-ballistic missile (ABM) systems. The ABMT limits the Parties to the testing (at agreed ABM test ranges) and deployment (at one deployment area) of fixed, land-based ABM systems and components. The Treaty allows 100 deployed ABM interceptor missiles and ABM launchers within the deployment area.

The ABMT explicitly prohibits sea-based ABM systems. The use of the Navy Theater Wide (NTW) system for National Missile Defense (NMD) would have to be considered in light of this prohibition. Article V.1 of the Treaty states:

> "Each Party undertakes not to develop, test or deploy ABM systems or components which are sea-based, air-based, or mobile land-based."

In its Theater Missile Defense (TMD) role, the NTW system is not limited by the ABMT per se. However, Article VI(a) of the Treaty states:

> "To enhance assurance of the effectiveness of the limitations on ABM systems and their components provided by this Treaty, each Party undertakes: not to give missiles, launchers or radars, other than ABM interceptor missiles, ABM launchers, or ABM radars, capabilities to counter strategic ballistic missiles or their elements in flight trajectory, and not to test them in an ABM mode; ..."

This provision prohibits giving non-ABM components ABM capabilities. The NTW Block I system, as it is currently configured, has been certified ABMT compliant. Any changes to the baseline program of the NTW Block I system, however, would be subject to review by the DoD ABM Treaty Compliance Review Group (CRG).

The use of NTW in support of an NMD system would raise significant ABM Treaty issues. The DoD has not assessed the compliance of such use. The DoD assesses the compliance of approved and sufficiently defined programs. However, the architectures and approaches discussed in this report are not under consideration for approval as a program by the DoD, and have not been submitted for compliance review.