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Report to Congress
on
Theater Missile Defense
Architecture Options
for the Asia-Pacific Region

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I. INTRODUCTION

PURPOSE

This report responds to the Fiscal Year 1999 National Defense Authorization Act which directs the Secretary of Defense to carry out a study of the architecture requirements for the establishment and operation of theater ballistic missile defense (TBMD) systems for Japan, the Republic of Korea (ROK) and Taiwan that would provide for their defense against limited theater ballistic missile attacks.

This report is not intended to discuss the overall development and production issues surrounding TBMD. Likewise, it does not discuss the criteria for arms transfers generally nor any particular issues surrounding transfers to Japan, ROK, or Taiwan. Finally, this report does not provide a comprehensive analysis of theater missile defenses in the Asia-Pacific region. Instead, as requested by Congress, it provides an overview of various TBMD architecture options, which could become available early in the next century. The defense of Japan, the ROK, and Taiwan against ballistic missile attacks is a complex topic and requires substantial in-depth analysis before definitive conclusions can be drawn. The goal of this report is to describe illustrative architecture options for Japan, the ROK, and Taiwan based on each one's unique political and military threat environments.

BACKGROUND

Preservation of peace and security in East Asia is a fundamental objective of the United States. The United States, with its allies and friends in the region, has deterred aggression and kept the peace through a number of bilateral alliances, through forward deployment of well-equipped armed forces and relationships with other forces in the region, through active diplomatic engagement, and through military response when necessary.

The spread of advanced military technology has the potential to undermine East Asian peace and stability, particularly when it comes to asymmetric capabilities like weapons of mass destruction (WMD) and ballistic missiles. As in other regions of the world, ballistic missiles with WMD warheads provide a military capability that has the greatest potential to put U.S. forward-based forces at risk and to threaten U.S. allies and friends. This threat is a concern to both the United States and to its allies and friends in the region.

To protect U.S. forces against theater ballistic missiles (TBM), the United States embarked on programs to develop and deploy improved ballistic missile defenses following the Gulf War. Some of our allies and friends in East Asia and elsewhere,

concerned by the growth of longer range, increasingly accurate and lethal theater ballistic missile systems and the threat they pose to their populations, have expressed an interest in how missile defenses might contribute to their own self-defense.

However, no decisions on deployment have been made other than for protecting forward deployed U.S. forces in the region. Any future decision by our allies or friends to develop and deploy advanced missile defenses must take into account a wide range of factors, including foreign policy interests, economic criteria, and domestic concerns. U.S. support for such decisions will be determined by their impact on U.S. security and interests and maintenance of peace and stability in the region.

In general, to deal with the new threat of WMD and theater ballistic missiles that can deliver them, the United States has developed a multifaceted counterproliferation policy and strategy. For East Asia, this policy is spelled out in the *1998 National Security Strategy for the East Asia-Pacific Region*. A key component of this policy and strategy is the ability to defend our forces against WMD and their means of delivery. The Secretary of Defense's recent announcement of DoD's intention to increase investment into theater missile defense systems reflects the importance we place on protecting our forward deployed forces.

The United States and several allies and friends already have some TMD capabilities, e.g., PATRIOT. In order to better defend its own forces, the United States is pursuing several TMD development programs and plans to deploy these advanced capabilities in layered defenses ("defense-in-depth") using air, land- and sea-based systems by the end of the next decade. The combination of air-, land- and sea-based boost phase, upper, and lower tier systems in an integrated architecture is referred to as the TMD Family of Systems (FoS). The FoS approach can provide multi-tiered defenses which are necessary to increase system robustness (kill probability) and efficiency (minimizing resource usage) against the large inventories of shorter range missiles (lower tier systems) as well as the longer range ballistic missiles (upper tier systems). For the FoS to function effectively, boost phase, upper- and lower-layer defenses must be supported by timely and accurate early warning and battle management/command control communications (BM/C³).

While layered missile defenses are expected to be very effective (especially against limited attacks), they may never achieve 100 percent probability of kill and therefore must be considered as only one component of our overall counterproliferation strategy which includes our extended nuclear deterrent and our conventional capabilities as key components.

The analytical conclusion in this study that certain hypothetical options could allow effective defense should not be construed as a recommendation to deploy TMD in East Asia by our allies and friends. Because the focus of this study is possible TMD

architecture, it does not address their feasibility or desirability from political, economic, or other security perspectives. A detailed discussion of these important facets of the issue is outside the mandate and scope of this paper.

The Department of Defense welcomes the opportunity to present this report as part of a continuing dialogue and discussion on the subject of TMD. DoD is committed to keeping Congress informed of developments on this subject, to include implications for its allies and friends.

II. OVERALL APPROACH

REPORTING REQUIREMENTS

Section 1533 of the National Defense Authorization Act for Fiscal Year 1999 directs the Secretary of Defense to carry out a study of the architecture requirements for a theater ballistic missile defense (TBMD) system in the Asia-Pacific region to protect key regional allies and friends of the United States. The Act specifies that the architectures in the study should include the description of any United States missile defense system that could be transferred to key allies and friends to provide for their self-defense against limited ballistic missile attacks. The Conference Report includes the understanding that this study should include Japan, the Republic of Korea (ROK), and Taiwan.

LIMITATIONS

Missile defense options for Japan, ROK, and Taiwan were developed and assessed separately based on the unique political and military threat environment confronting each one. The architecture options analyzed for each entity in no way suggest or imply a region-wide architecture network. The architecture options presented do not address protection of U.S. forward deployed forces. In addition, this study did not include U.S. TBMD forces that may be deployed in the region nor defense of U.S. critical military assets in the region. The report does not advocate or recommend deployment of any specific TMD architecture, including those discussed in the report.

The architectures utilize representative TBMD systems now under development (i.e. PATRIOT PAC-3, Navy Area Defense, Theater High Altitude Area Defense {THAAD} and Navy Theater Wide {NTW} similar to the Block I and Block II systems). Lower tier systems are expected to become operational beginning early in the next decade. Upper tier TMD systems are in the engineering and development phase and initial operational capability is not expected until after 2007. Due to time constraints, the report does not examine boost-phase intercept systems like Airborne Laser (ABL) and Space-Based Laser (SBL). Also, there was insufficient time to examine the effects of suppression of TBMD systems by a potential aggressor, robustness against maximum aggressor raid sizes, or countermeasures which could be employed on theater ballistic missiles (TBMs).

TECHNICAL METHODOLOGY

Table 2-1 identifies the TBMD systems used in this analysis. The performance of the lower and upper tier systems in the analysis was similar to, but not exactly like, the U.S. TBMD systems currently under development. The system representations used were sufficient for an illustrative architecture study.

Table 2-1. Classes of Systems Available for Deployment

System Class	U.S. System
Land-Based Lower Tier	Similar to PATRIOT PAC-3
Sea-Based Lower Tier	Similar to Navy Area Defense
Land-Based Upper Tier w/Fire Control Radar And Endo-Exo Missile	Similar to THAAD (THAAD Missile And TMD-GBR)
Sea Based Upper Tier w/Exo Missile	Similar to NTW SM-3 Block I Missile And AEGIS SPY-1 Radar
Sea-Based Upper Tier w/Fast Exo Missile	Similar to NTW Block II System

The primary measure of effectiveness for the architecture alternatives undertaken in this study was defended area. The force structure derived, for each illustrative architecture, in this study could reasonably be expected to provide area coverage for each defended area against a limited attack by the different types of TBMs likely to be arrayed against it.

This report quantifies the architecture force structure needed to provide coverage against specific theater ballistic missile threats to most of the territories for Japan, South Korea, and Taiwan. This defense also provides protection of the critical assets identified by the U.S. intelligence community.

A source of early warning is essential for the effective operation of any theater missile defense architecture. Early warning also permits effective implementation of passive measures, such as civil defense and dispersal of aircraft. In many cases, an optimal early warning configuration is a combination of overhead surveillance and long range phased array early warning radars thereby introducing a measure of redundancy, reducing opportunities for false indications of missile launches and increasing survivability. Each of these methods provides the fire control radar a cue, allowing earlier detection and engagement of the threat TBM. Of course, this cueing implies a

communication system and a procedure for removing biases between the different sensors.

To determine the defended area for a particular architecture in a given country, sample threat launch points were chosen for each of the different types of TBMs. A grid was then overlaid on the map of each defended territory. The required force structure was estimated and its TBMD assets deployed. Each threat flew a simulated trajectory, within its range capabilities, to the center of each grid square in the defended territory. A particular grid square was considered covered or defended if the defending assets in the architecture could intercept all of the feasible trajectories from every threat launch point to the center of that grid square. If even only one threat trajectory could reach a particular grid square without being negated by the deployed TBMD assets, that grid square was considered unprotected by that particular architecture. The process was repeated, until the greatest defended area was achieved with the fewest fire units. This process is shown in Figure 2-1.

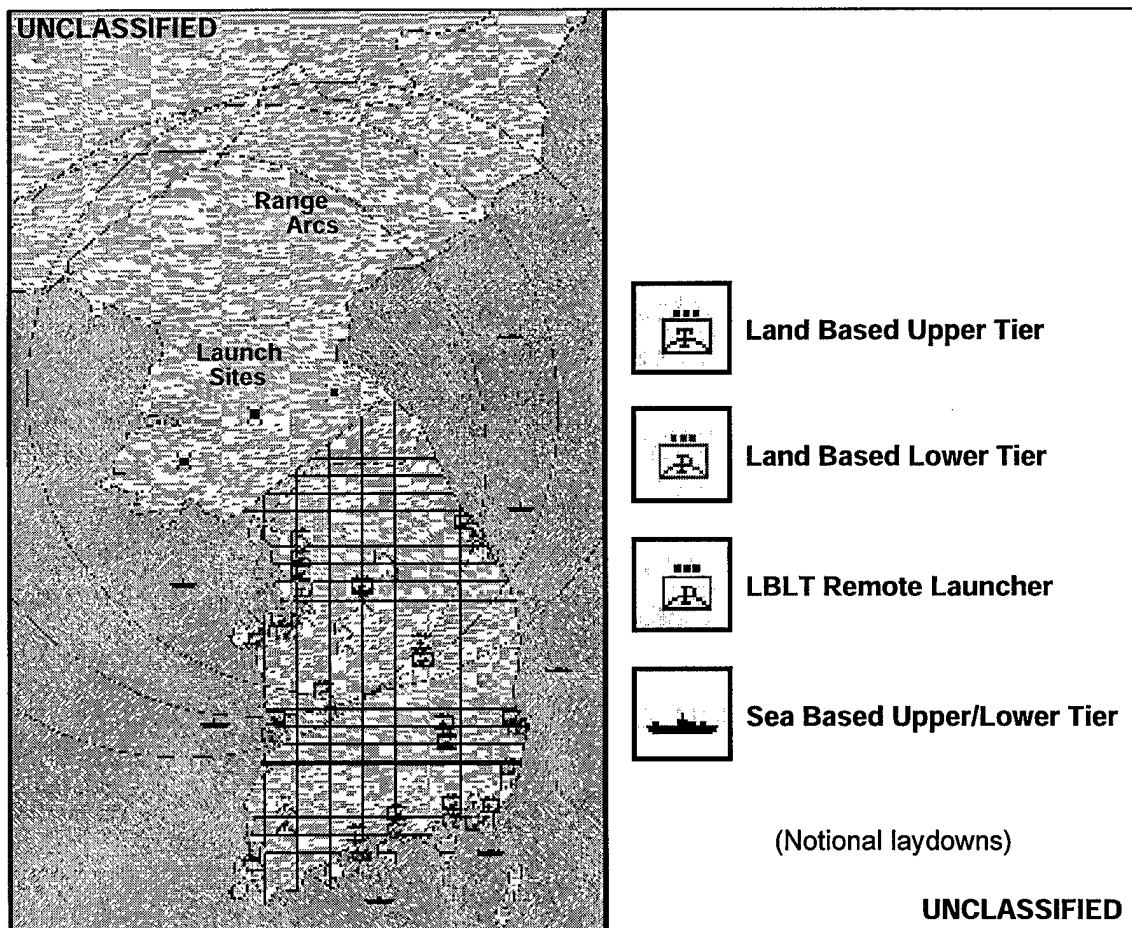


Figure 2-1. Calculating the Battlespace Coverage

III. JAPAN

BACKGROUND

Japan has been engaged in a ballistic missile defense dialogue with the United States since 1987 when the two countries signed an *Agreement Concerning Japanese Participation in Research for the Strategic Defense Initiative*. Since 1987, BMDO sponsored two joint industry studies, which recommended a two-tiered TMD architecture.

In December 1993, a *U.S.-Japan TMD Working Group (TMD WG)* was created under the Security Sub Committee, Security Consultative Committee (SSC-SCC) to provide a forum for regular discussion of TMD and TMD-related matters such as regional political implications and treaty compliance. In October 1994, a Government of Japan-led *U.S.-Japan Bilateral Study on Ballistic Missile Defense* was initiated; the study provided extensive simulation and systems analysis to identify and evaluate various missile defense alternative architectures. The results identified and evaluated specific Japanese TMD-related technologies associated with the U.S. Navy Theater Wide TBMD program and their related capabilities that would enhance U.S. TMD systems development.

ARCHITECTURE OPTIONS

Geographic Features

Geography is the predominant factor to be considered in designing the architecture requirements and options for defense of Japan. There is a sea barrier of about 1,000 km between most of Japan and North Korea. To traverse this distance, a TBM launched against Japan must travel a substantial part of the way exo-atmospherically.

Flight Characteristics of North Korean Missiles

The extended period of flight that the North Korean TBMs spend in the exo-atmosphere provides upper tier TBMD systems ample engagement opportunities (shoot-look-shoot coverage in many defended areas) and deployment flexibility (ships can be positioned for either ascent, midcourse or descent phase defense).

North Korea could attempt to attack most of Japan over a large attack azimuth, from east-northeast to directly south, in a relatively limited arc of ballistic missile ranges (1000-1500 km). The North Korean threat would come from a concise attack area, which limits the radar search requirement. All architecture examined here would have organic sensors capable of satisfying this requirement.

Results of Architecture Analysis

Four different architecture options were examined for the defense of Japan. Only one option used only a lower tier system. It was analyzed to indicate how many sites would be required to defend the entire nation. The other three alternatives analyzed were upper tier systems.

The first option studied was a land-based lower tier system similar to the PATRIOT PAC-3 system integrated with a THAAD-like radar which could provide cueing. The purpose of this examination was simply to demonstrate the large number of fire units that would be required to accomplish a ballistic missile defense for Japan. Even using cueing information from a THAAD-like radar and remoting the PAC-3-like launchers (to provide extended battlespace), more than one hundred PAC-3-like fire units would be needed for a country-wide defense of Japan.

The remaining options examined addressed only upper tier systems. A deployment of six land-based endo-exo upper tier systems, similar to the THAAD system, would provide coverage of nearly all of Japan. An alternative configuration, consisting of four fire units, coupled with three additional THAAD-like radars, could also cover nearly all of Japan.

Two sea-based exo-intercept systems, similar to the NTW Block I and anticipated Block II systems, were also analyzed. For a NTW Block I-like system, four ship positions would provide nearly complete coverage of Japan with substantial shoot-look-shoot opportunities over much of Japanese territory. With the faster missile and better kill vehicle typical of the NTW Block II-like system, which would allow expansion of the engagement volume, an even more efficient deployment would be possible. One ship position is sufficient to provide full national coverage. The interceptor speed would allow this system to provide a shoot-look-shoot engagements over the central portion of the country.

Summary

A summary of the illustrative force structure analysis is shown in Table 3-1. For a lower tier only architecture, the number of systems that would be required for full coverage of Japan is deemed impractical. For the upper tier systems, the number of fire units/ships required is noted. All three of the upper tier architectures could provide coverage of Japan. Additional TMD units could increase the efficiency with which the inventory is expended by providing more shoot-look-shoot opportunities.

Table 3-1 Architecture Force Structure Illustrations For Defense Of Japan

Architecture Class	Number Of Upper Tier Assets	Number Of Lower Tier Assets
Land Based Lower Tier	N/A	>100*
Land Based Endo-Exo Upper Tier Missile / Upper Tier Radar	6 (or 4 batteries + 3 radars)	N/A
Sea Based Exo Missile Upper Tier / Sea-Based Upper Tier Radar	4	N/A
Sea Based Exo Missile Upper Tier Fast Missile / Sea-Based Upper Tier Radar	1	N/A

*For Complete Coverage Of Japan

IV. REPUBLIC OF KOREA

BACKGROUND

The United States continues to be concerned over the ballistic missile threat to the Republic of Korea (ROK) and is prepared to cooperate with our ally in developing effective means for addressing this dangerous threat.

ARCHITECTURE OPTIONS

The architecture requirements for the defense of the ROK against North Korean missiles reflect the geography of the Korean peninsula and the theater ballistic missile capability of North Korea.

Geographic Features

The key geographic features dominating the architecture requirements and options for the defense of the ROK are the close proximity of the capital Seoul to the North Korean-ROK border and the relatively small size of the Korean peninsula. Home to more than 25 percent of the ROK's population, Seoul is only some 40 kilometers (24 miles) south of the Demilitarized Zone (DMZ) and within easy range of all the ballistic missiles considered in this study. The ROK is relatively small, with a north-south length of roughly 380 kilometers and an east-west width of 260 kilometers. North Korea is slightly smaller. As a result, the ranges of the ballistic missiles that can be used are restricted.

Flight Characteristics of North Korean Missiles

All the missile trajectories used as the baseline in this study are nominal. The short range ballistic missile trajectories would have to exit the atmosphere (ie. achieve an altitude of more than 100 kilometers) to be accessible to exo-only upper tier systems.

Results of Architecture Analysis

Five different architecture options were examined for the defense of the ROK against North Korea. These were selected to be the simplest possible options from the collection of different combinations of systems that could have been used.

The first option examined was a land-based lower tier system similar to the PATRIOT PAC-3 system, using remote launchers at most sites to extend their coverage. The size of the force deployed was selected to cover the assets identified as critical. More of South Korea could be covered with a larger deployment.

The second option was a sea-based lower tier system, similar to the Navy Area system. Such a system could provide protection to the coastal targets, but could not reach far enough inland to defend all critical assets and population centers against all threat trajectories.

The other options examined used upper tiers in conjunction with a land-based lower tier system. The lower tier system would be necessary because the upper tier could not intercept ballistic missiles targeted on Seoul.

Using four upper tier endo-exo batteries (similar to the THAAD system) and seven lower tier batteries (similar to the PAC-3), all of the country beyond the immediate reach of very short-range ballistic missiles could be covered. The critical feature for the coverage achieved by this architecture is the minimum intercept altitude of the endo-exo upper tier system. Able to intercept TBMs flying to an apogee as low as 40 kilometers, the endo-exo upper tier system could reach most of the threatening trajectories. The lower tier system would be used to protect Seoul and its environs.

With a minimum intercept altitude of about 100 kilometers, the sea-based upper tier exo systems could not defend the northern two-thirds of the ROK against the low flying short range TBMs. Irrespective of the number of ships or interceptor velocity, the exo-atmospheric TBMD architectures would be denied intercepts against most TBM threats due to the low apogee when flying short ranges.

Summary

Table 4-1 summarizes the analyzed force structures.

Table 4-1. Architecture Force Structure Requirements for Defense of South Korea Against North Korea

Architecture Class	Number Of Upper Tier Assets	Number Of Lower Tier Assets
Land Based Lower Tier	N/A	25
Sea-Based Lower Tier	N/A	11
Land Based Endo-Exo Missile Upper Tier / Upper Tier Radar + Land Based Lower Tier	4-Many	7
Sea Based Exo Missile Upper Tier / Sea-Based Upper Tier Radar + Land Based Lower Tier	1-Many*	25
Sea Based Fast Exo Missile Upper Tier / Sea-Based Upper Tier Radar (SBZM / SUR) + Land	1-Many*	19

Based Lower Tier		
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*No Access By Exo Systems Except To Long Range Threats To Southern Quarters
Of South Korea Due To Exo Minimum Intercept Altitude

For each architecture option, the minimum force structure is shown in the two columns. The "-Many" terminology simply indicates that additional upper tier firing units would not appreciably improve the coverage for the particular architecture option examined. In the case of the THAAD-like endo-exo upper tier system, the high endo minimum intercept altitude would preclude engagements for threats attacking the northern portions of the ROK. For the sea-based upper tier systems, the exo-atmospheric minimum intercept altitude constraints would prevent engagements of the threats to all but the southern portions of the ROK (i.e., most North Korean threats attacking the ROK do not fly high enough for the exo upper tier systems to engage them).

V. TAIWAN

BACKGROUND

The U.S. has interests in the development of improved cross-Strait relations and the peaceful resolution of disputes between Chinese on both sides of the Taiwan Strait. Continued increases in PRC missile deployment, however, will complicate our efforts to maintain this environment. While adhering to the terms of the U.S.-PRC joint communiqués, the Department of Defense seeks to provide sufficient defense capability to Taiwan consistent with the requirements and intentions of the Taiwan Relations Act. At the same time, we encourage PRC self-restraint in the deployment of offensive weapons, especially theater ballistic missiles.

The Taiwan Relations Act (TRA) serves as the basis for our unofficial relations with Taiwan. The TRA stipulates that "the United States will make available to Taiwan such defense articles and services in such quantity as may be necessary to enable Taiwan to maintain a sufficient self-defense capability." The TRA states that "the President and Congress shall determine the nature and quantity of such defense articles and services based solely upon their judgement of the needs of Taiwan, in accordance with procedures established by law." The TRA further asserts that "such determination of the Taiwan's defense needs shall include review by the United States military authorities in connection with recommendations to the President and the Congress."

To date, Taiwan has expressed interest in an improved early warning capability and additional technical information on their current capabilities, future requirements, and potential cost associated with establishment of a TBMD architecture. Taiwan has already deployed Modified Air Defense System (MADS), a PATRIOT derivative which provides some very limited point defense against short range ballistic missiles.

As outlined in this report's opening comments, we do not address the full range of complex political, economic, and technical factors associated with the establishment of a TBMD architecture. Future decisions by Taiwan in the area of missile defense most likely will reflect judgments concerning both PRC political intentions and the nature of the evolving threat, balanced against the costs and the ability of such systems to adequately defend against that threat. Taiwan's decisions may result from a mix of factors: the perception of a need to counter a missile threat; a politically driven need by democratically elected leaders to be seen as responsive to such a threat; the operational effectiveness of, and actual and opportunity costs of acquiring such a system; and the risk of heightened cross-Strait tensions. Should the cross-Strait relationships improve, then the salience of the missile threat may decline.

Should Beijing use its ballistic missile force, it has a range of options from which to choose. These options range from limited firings of 1-3 missiles targeted off the coast of Taiwan to medium scale firings of several missiles at military targets on Taiwan, to larger scale salvos against multiple targets. The option taken would depend on Beijing's assessment of the situation and their objectives.

ARCHITECTURE OPTIONS

Geographic Features

The key geographic feature dominating the architecture requirements and options for the defense of Taiwan against China is the short 175 km sea barrier between Taiwan and China. Shorter range missiles (range < 300 km) could fly over that barrier and remain inside the atmosphere for the entire trajectory. With the size of China, an attack could come from multiple directions. Moreover, China possesses theater ballistic missiles with longer ranges (~3000 km). These features make early warning surveillance for cueing purposes essential for an effective missile defense.

Flight Characteristics of PRC Missiles

Development of Taiwan missile defense architecture options was based on short and medium range ballistic missile threats which are expected to increase significantly over the next several years. Both of these missile types have apogees outside the atmosphere. The medium range missile also has a re-entry speed likely to preclude a high probability of intercept by lower tier systems.

Results of Architecture Analysis

Five architecture options were examined for the defense of Taiwan. An analysis was made of the capabilities of the lower tier land- and sea-based architectures. Against shorter range TBMs, either lower tier system could adequately defend most of Taiwan's critical assets. However, neither architecture could provide any defense against longer range TBMs.

To address the full range of threats, three land- and sea-based upper tier options were explored. One land based upper tier fire unit, with an additional THAAD-like radar would be able to cover the entire island of Taiwan. This system could intercept incoming missiles both inside the atmosphere (endo-atmosphere) and outside the atmosphere (exo-atmosphere). This architecture is referred to as an endo-exo option.

Either sea-based upper tier exo system could cover all of Taiwan. Only one ship position is required for either sea-based exo upper tier system. The fast exo upper tier system would also provide shoot-look-shoot coverage for portions of Taiwan.

Summary of Architecture Options

A summary of the active theater missile defense force structure options is shown in Table 5-1.

Table 5-1. Architecture Force Structure Requirements

Architecture Class	Number Of Upper Tier Assets	Number Of Lower Tier Assets
Land Based Lower Tier	N/A	>12* / N/A**
Sea-Based Lower Tier	N/A	11* / N/A**
Land Based Endo-Exo Missile Upper Tier / Upper Tier Radar	1 + 1 Extra THAAD-Like Radar	N/A
Sea Based Exo Missile Upper Tier / Sea-Based Upper Tier Radar	1	N/A
Sea Based Fast Exo Missile Upper Tier / Sea-Based Upper Tier Radar	1	N/A

*Coverage Against SRBMs Only

**No Capability Against Longer Range TBMs