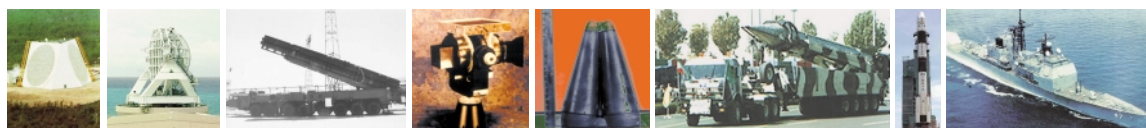
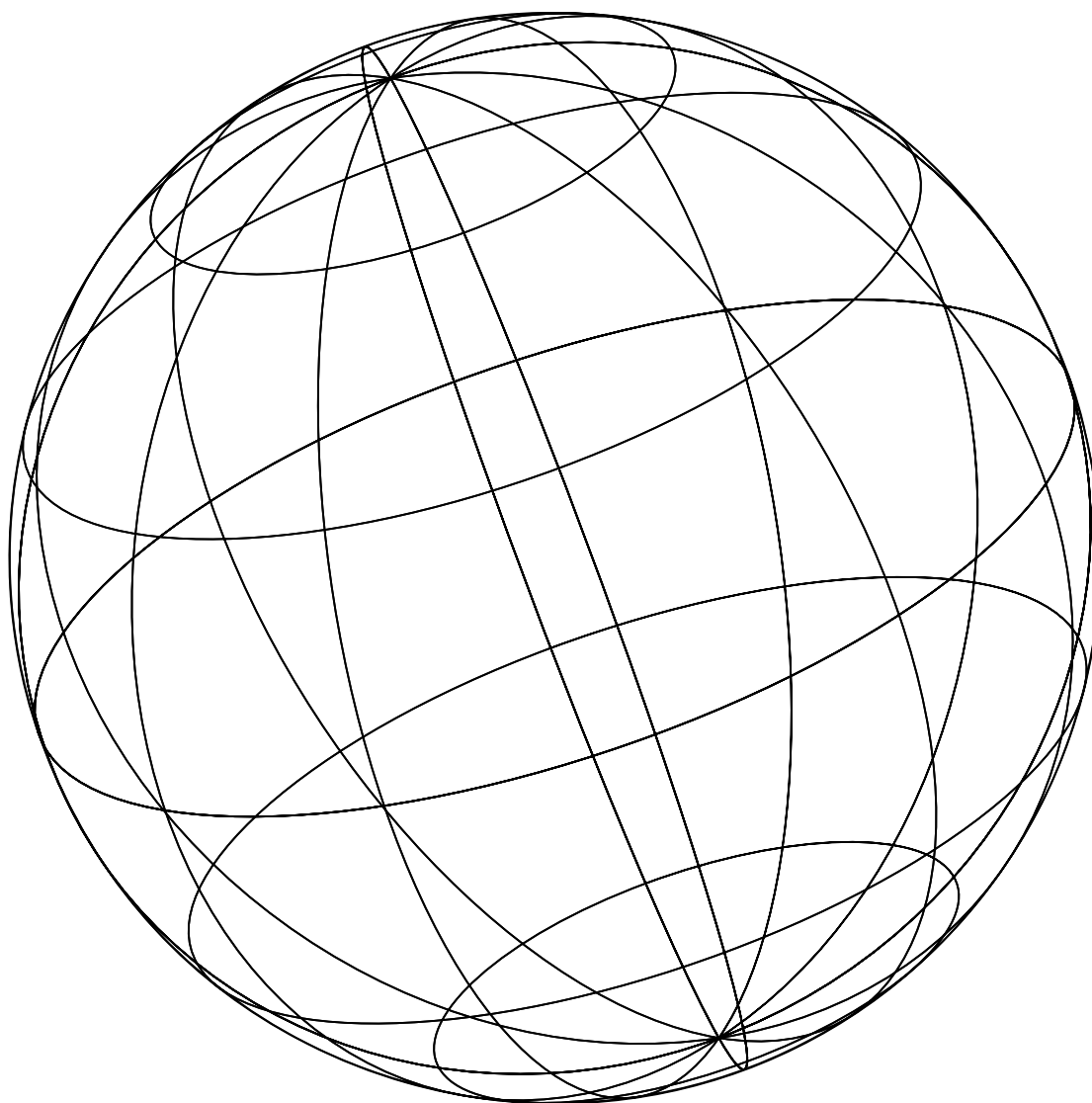


July 2000
FINAL EDITION

a study on:

National Missile Defense:

Policy Issues and Technological Capabilities



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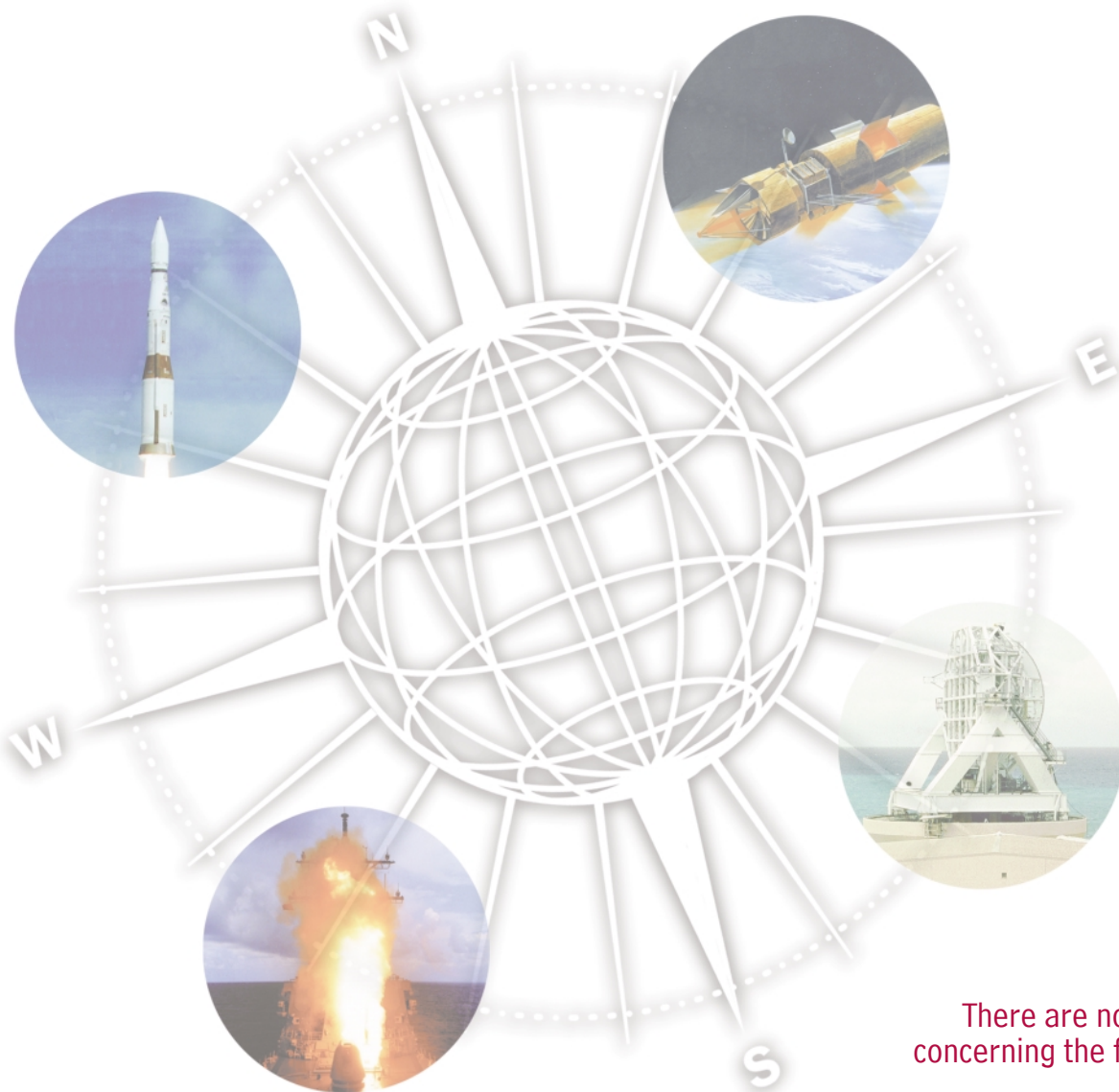
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National Missile Defense:

Policy Issues and Technological Capabilities

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There are no facts
concerning the future.



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The possible deployment of a U.S. national missile defense is the object of increasingly intense debate. For the United States, the long-delayed hour of decision is now approaching. The nation's policy makers must decide whether or not to deploy a national missile defense.

The points of contention include:

- The extent that the threat situation warrants the establishment of an NMD system;
- The potential impact such a system might have on legacy arms control agreements;
- The likely reaction to a U.S. deployment decision by other missile powers (e.g., Russia and China);
- The implications of NMD for U.S. relations with allies;
- The readiness for deployment of the technology needed to perform NMD interceptions reliably; and
- The type and the extent of needed missile defenses.

For the most part, the disputes over the nature and extent of emerging missile threats are diminishing. The previous comprehensive missile defense study issued by the Institute for Foreign Policy Analysis (IFPA) in April 1997, *Exploring U.S. Missile Defense Requirements in 2010*, set forth the changing threat environment. Reportedly, this study became a major factor in coalescing policy

opinion on the need for an official independent assessment of the emerging missile threat. As such, it provided some of the impetus behind the establishment of the Rumsfeld Commission, whose report largely ended any serious opposition to the fact that missile proliferation was occurring at a faster rate than had been previously acknowledged. IFPA's report also was a factor in the decision by the Alaskan Legislature in June 1997 to pass a resolution calling for the deployment of an effective national missile defense capable of protecting all 50 states.

Unfortunately, the other non-threat related political and technical issues listed above are still being hotly debated, sometimes with more fervor than fact. In an attempt to shed more light on issues still unresolved, we at IFPA have produced this the latest of our missile defense studies. Like its predecessors, it is designed to pull together in a single unclassified document the core issues associated with missile threats, arms control, U.S. security policy, and national missile defense technologies.

This study was developed over the course of 18-months of thoughtful effort, an effort that relied solely on open source documents and unclas-

sified statements or personal interviews. Those working on this study remained totally isolated from any classified material that relates to the issue. Although the information contained in this document undoubtedly contains some slight differences in fact from that found in classified files, we believe that this report represents the most comprehensive collection of open source NMD information and analysis now available in a single document. We have attempted to approach the issues with an open mind and treat the subject matter in a balanced manner.

The study is intended to provide a blueprint that could be used to build a consensus among the disparate NMD requirements and potential responses now advocated. Clearly, current U.S. policy is stalemated between the arms control and the missile defense poles--it is a position that cannot long endure without endangering U.S. national security.

It is now NMD decision time. In the words of Shakespeare, "To be or not to be, that is the question." For NMD, that is the precise question to be answered. This study provides new perspectives on the potential response to that question, and does so within a broader strategic context that should frame U.S. counterproliferation and overall national security policy in the years ahead.

Robert L. Pfaltzgraff, Jr.
President, IFPA
July 5, 2000

This study provides a comprehensive overview of national missile defense (NMD) issues now under discussion. Threats, arms control issues, missile defense technologies, the current NMD program, and NMD alternative options are all discussed. Chapter 6 contains the findings and recommendations that point out the strengths and weaknesses of the programs and policies now being pursued and set forth new concepts for NMD as part of broader national security policy.

Chapter One: Introduction

The post-Cold War international security environment has solidified into a unipolar structure, a condition many states would like to change. A key factor in the current proliferation movement is the overwhelming military superiority of the United States. The unintended consequence of successful U.S. military actions from the Gulf War through the Kosovo air campaign has been to convince other states that conventional weapons alone cannot check U.S. power. This observation is leading a number of states to focus their military procurement efforts on the acquisition of asymmetrical military capabilities. As a result of this shift in focus, the major security challenges that the United States itself is most likely to face during the next decade or two include:

- A terrorist-style threat using WMD
- Long-range cruise missile threats
- Information warfare attacks (to include threats to space assets)
- Ballistic missile attack or threat of attack with WMD payloads

In addition, as new states join the missile club, neighboring states are becoming concerned; some are acting to develop their own retaliatory capabilities. Consequently, proliferation rates are increasing with some of the activity being conducted by U.S. allies. As more states join the missile club, the number of potential suppliers of missile technology also grows.

If the United States is to enjoy some measure of security in the years ahead, each of these potential threats must be countered. Of the potential threats listed, ICBMs are the only lethal capability that can be used to threaten (directly or indirectly) another sovereign state on a global scale without deployment to a forward location—a movement that would signal escalation, perhaps leading to war. Ballistic missiles are also the only potential threat for which there are no countermeasures now available other than retaliation or preemptive strike (see figure 1, p. vi).

Missile and WMD technology transfers are an increasingly important factor in the post-Cold War security calculus. Both Russia and China have lost central control over many of the industrial activities on their soil; both states also have a declared policy to work together to bring about a multipo-

lar international structure. *The clear implication of such a policy is that the United States must be weakened and additional centers of power must be established if a multipolar structure is to emerge. Russian and Chinese actions of both omission and commission reflect such a strategic goal.*

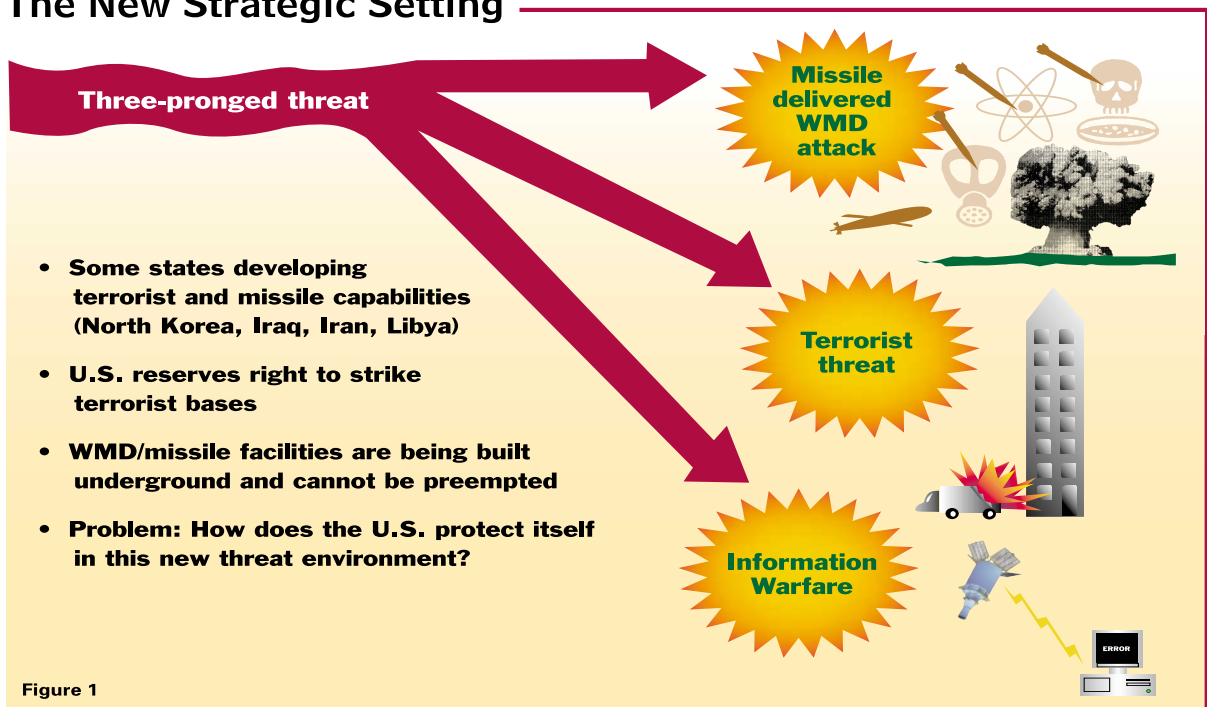
During the years ahead, it is likely that Russia will continue to lose military capability as it struggles to revive its economy. Although Russia's large nuclear arsenal will ensure that it remains the largest potential threat to U.S. security for many years to come, the threat of a Russian missile strike against the United States has greatly diminished. With little to gain and much to lose from a nuclear strike against the United States, the principal threat of such an attack from Russia would be as a result of a false alarm of incoming U.S. missiles or an unauthorized launch of one or more Russian missiles.

In the case of China, Beijing's missile development activities point toward the future emergence of a strategic strike force larger than the two-dozen ICBMs it is reported to have deployed as of the end of 1999. The new ICBMs and SLBMs are expected to be equipped with multiple reentry vehicles that China is now developing. These

activities point toward the possible deployment of several hundred strategic warheads by 2010-2015. What is more disturbing is an evolving Chinese viewpoint that sees nuclear weapons as usable warfighting systems. This view is tied to some Chinese postulations that future nuclear exchanges could involve limited nuclear strikes and proportional counterstrikes (e.g., a Los Angeles for Taipei scenario). Under these conditions, the side with the greatest resolve would win.

As detailed in chapter 1, missile technology is spreading around the rimlands of Eurasia. It is clear that the United States and many of its allies are or will be threatened by these systems in the future. Unless some event occurs to change the current trend, Russia, China, and North Korea will continue to proliferate missile technology and related hardware to other states during the coming decade. If North Korea successfully develops a three-stage ICBM, it should be expected that the missile would not only threaten the U.S. from North Korea, but likely would be exported to other states of concern. Clearly, the ability of additional countries to threaten the U.S. with ballistic missiles would make it increasingly difficult for the world's remaining superpower to defend its national interests, including: maintaining global

The New Strategic Setting



stability, slowing the rate of WMD and missile proliferation, protecting access to oil, deterring terrorism, and providing believable security guarantees to allies.

Chapter Two: U.S. Policy: The Arms Control and NMD Dichotomy

For better or worse, many of the legacy arms control agreements of the Cold War era are crumbling, and U.S. policy makers are divided on how to respond. U.S. security policy is caught between shoring up weakened arms control regimes and establishing a national missile defense, the type and extent of which is subject to disagreement. The compromise language used in the National Missile Defense Act of 1999 supporting both NMD and continued negotiated reductions in Russian nuclear forces reflects this dichotomy. There is a possibility that the lack of policy consensus on how to proceed in the future could produce the worst of both worlds: a fig-leaf NMD system coupled to an obsolete arms control structure, with neither being capable of dealing effectively with evolving proliferation challenges.

The ABM and START treaties are intertwined with the NMD deployment decision. Russia has tied its continued participation in the START treaties to U.S. adherence to the ABM treaty. Russia also promises to negate the effectiveness of any U.S. NMD system deployed by improving its own offensive capabilities. Russia's position is clearly part of a diplomatic offensive designed to persuade the U.S. not to deploy an NMD system.

The Russian *Duma* had long resisted START II ratification, primarily because of that treaty's prohibition on multiple reentry vehicles on ICBMs. To field the START II force structure would require that Russia build about 1500 new missiles to replace those systems becoming obsolete and to carry the single-warhead payloads specified by the treaty (see page 2.6). Currently, the production rate for Russia's new SS-27 ICBM is about 10 missiles per year. To maintain strategic parity with the United States, Russia hopes to drive the START III warhead limits to much lower levels than the U.S.

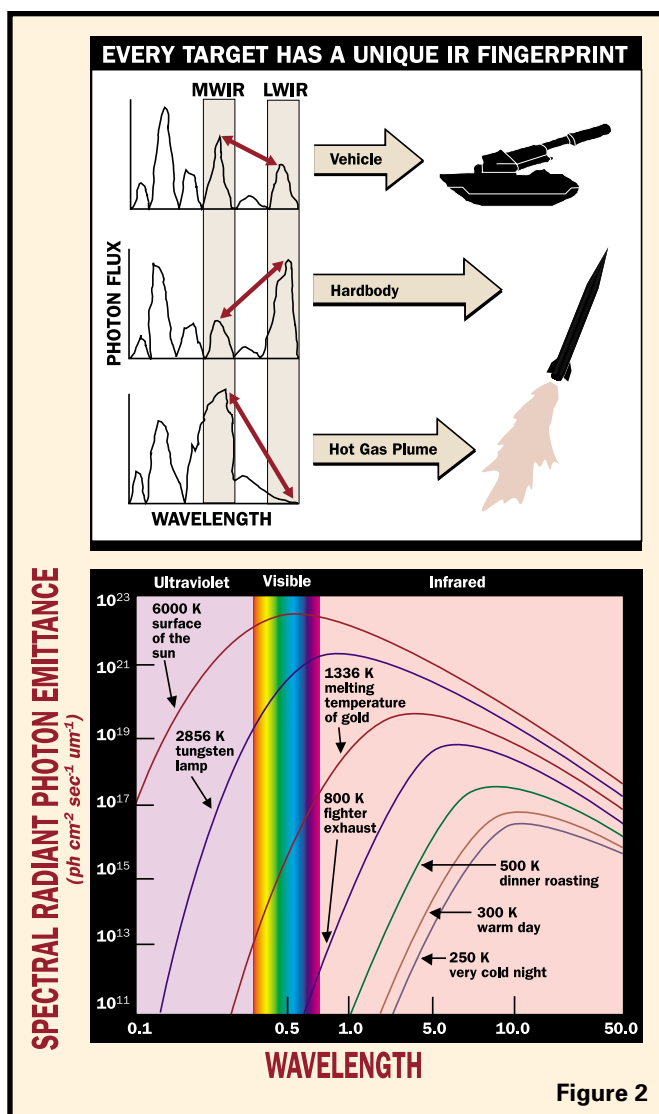
has indicated it is willing to accept. Russia also wants START III to allow three or so multiple warheads to be mounted on the new SS-27 ICBMs. However, the United States had refused to begin START III negotiations until the START II treaty was ratified by Russia.

The *Duma's* ratification of the START II treaty on 14 April 2000 contains some "poison pill" provisions that will likely prevent that treaty from entering into force, while still ensuring that START II will create more obstacles for the U.S. NMD deployment decision process. Russia's START II ratification stipulates that the treaty not enter into force until the United States ratifies the 1997 ABM Treaty demarcation agreements and the START II extension protocol. The U.S. Senate has previously signaled that it would not ratify the demarcation agreements if the administration submitted them to the Senate for a vote. In addition, the *Duma's* START II ratification also contains a declaration making U.S. failure to abide by the provisions of the ABM treaty a provocation that would cause Russia to withdraw from the START II treaty.

China also poses a potential problem in that it could react to the deployment of an NMD system by building up its strategic missile forces and increasing its rate of missile technology transfers to other states. Since the U.S. engagement policy is designed to lead China toward a peaceful transition to a democratic system, the United States clearly would like to avoid pushing China toward proliferation activities certain to raise Sino-American tensions.

In trying to resolve the U.S.-Russian dispute over START and the ABM treaty, at least four potential U.S. courses of action have been suggested (specified on pages 2.7 to 2.11):

- 1) Terminate the ABM treaty (two methods)
- 2) Negotiate the minimum treaty changes needed for an initial NMD deployment
- 3) Subsume the ABM issues into the new START III negotiation
- 4) Unilaterally reinterpret portions of the ABM treaty



The Clinton administration has followed option two, but it also finds option three attractive. The main problem with option two is that it sets up the NMD issue to be a continual source of friction in U.S.-Russian relations for years to come. Each time the ABM treaty must be modified to respond to a changing threat situation, the treaty will have to be renegotiated.

A potential pitfall in the above situation is that Russia clearly wants to maneuver the United States into a START III negotiation that would reduce strategic nuclear warhead levels to 1000 reentry vehicles (the U.S. does not want to go below 2000 RVs). Convincing the United States to reduce its START III warhead ceiling to a level below 1500 warheads would reduce the United

States' strategic capabilities to a point that might be challenged by China (it has the fissile materials needed to match such a level). Since a bilateral agreement would only apply to Russia and the United States, it would do nothing to slow proliferation activities around the globe, and it could contribute to the emergence of additional centers of power capable of asymmetrically challenging the United States' military capabilities.

Russia's apparent preferred outcome to the ABM and START issues outlined above would bind the United States in a bilateral agreement at a time when the world is changing dramatically. If the United States entered such an agreement without any accompanying restrictions on Russian, Chinese, and North Korean global proliferation activities, or on the strategic development programs of states such as China, the United States could find itself in an increasingly precarious security situation. At the heart of the issue is the pressing question, what is the underlying U.S. policy for dealing with both proliferation and excessive U.S.-Russian nuclear capabilities? Much of the current debate focuses on one or the other side of this issue, but both fail to address the entire problem: how should arms control and NMD fit together to maximize U.S. security?

Chapter 3: Understanding NMD Technology

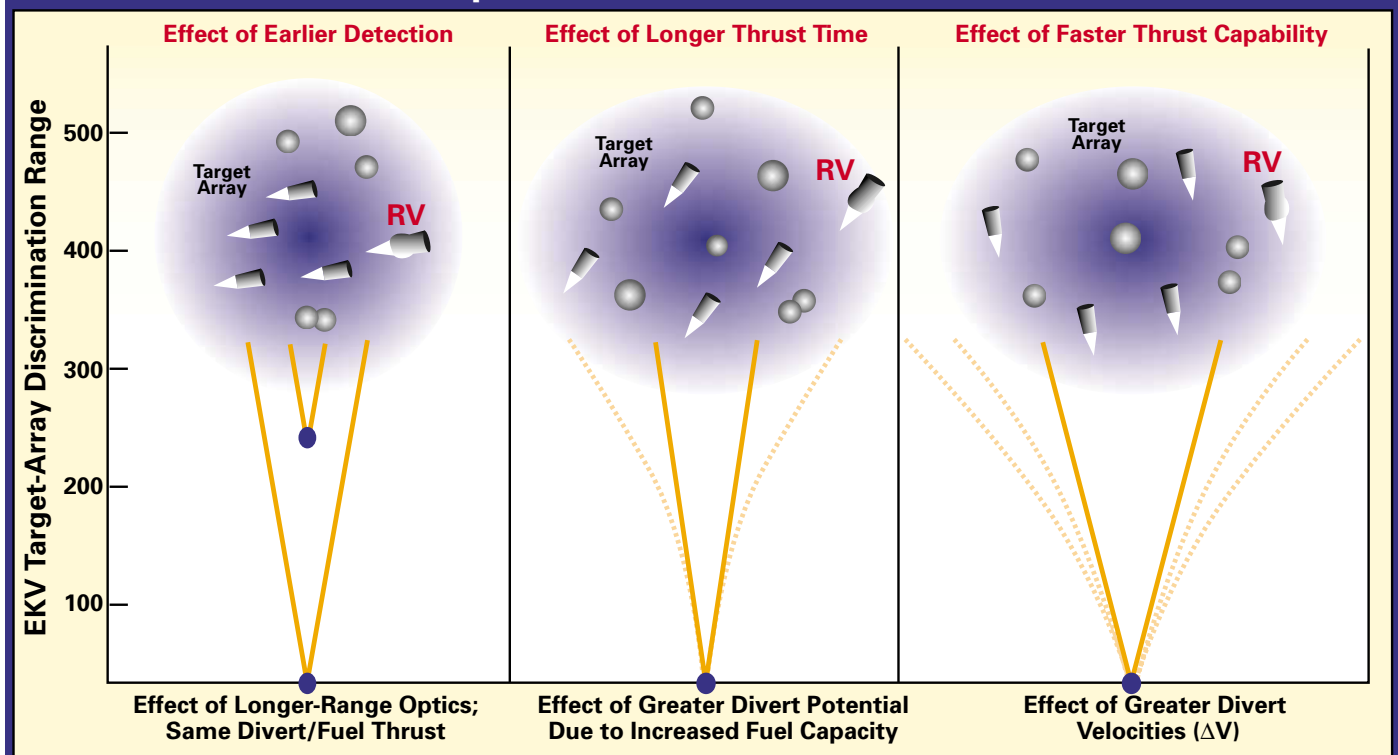
The policy deliberations over how to handle the issues cited above have incited a disagreement over the technological readiness of the NMD program. As a result, the policy community has become engaged in a debate that encompasses technological questions outside the boundaries that normally delineate strategic policy deliberations. Consequently, this chapter reviews penetration aid (penaid) options, explains how infrared and radar technologies work, and describes the capabilities and functioning of each of the NMD components. It is recommended that policy makers take some time at least to skim this chapter since the material is not easily summarized.

There are three points discussed in this chapter that warrant special attention:

- The critical NMD technologies are the sensors and processing systems that link them together. The sensors being developed for NMD use infrared (IR) and radar (microwave and laser) technologies. *The highest degree of target-array discrimination occurs when the data from both IR and broadband, high-frequency radar are fused together into a composite picture of a target array. It is much easier for offensive-missile engineers to develop countermeasures against a single type of sensor than it is to defeat two or more different sensor types that are working together.* For example, an effort to decrease an IR signature can result in making the object more visible to radar. *Under current plans, this dual radar-IR discrimination capability will not be deployed and made operational until the initial NMD system is upgraded around 2010 (some of the technology needed for the upgrade is still being developed).*
- If an IR sensor only measures the signature of a target array using a single IR color (one wavelength), it could easily be spoofed because the sensor would tend to identify the brightest object in the target array as the reentry vehicle (the object with the most intense signal—it might be a flare). *To discriminate a complex target array requires a multicolor IR sensor.* All objects in the universe emit a distinct IR signature—see figure 2. To plot the signatures requires IR measurements in multiple colors. In addition, the sensitivity of the IR sensor and its optical system determine how far away cold-body objects can be detected. This is a critical issue in terms of determining the effectiveness of the proposed interceptor system—see figure 3. In assessing alternative NMD systems, the internal capabilities of various kill vehicles must be understood (e.g., the relative capabilities of a LEAP kill vehicle versus the EKV).
- A number of technologies must be developed if the NMD system is to have the robust capabilities needed for the future. This is especially true of technologies capable of defeating early-release submunitions, for example. Unfortunately, only about one-third of the technology development projects critical to future NMD capabilities are now being funded. This issue is discussed on pages 3.29 to 3.31.

Kill Vehicle Divert Envelopes

Figure 3





Chapter 4: The NMD Program

The current program would establish an initial 20-interceptor capability in Alaska by 2005, expand it to 100 interceptors by 2007, then upgrade the capability with additional X-band radar systems and by establishing a second site with another 100 or so interceptors (probably at Grand Forks, ND) around 2010-2012. The sites being considered for the radar and the communication systems are

shown in figure 4. As noted earlier, the initial NMD system will not be fully capable of handling advanced target arrays. It is designed to defeat the capabilities of emerging missile powers and to field a system that can be upgraded to destroy more complex target arrays in the future as some needed technology is further developed.

If an accidental launch of a complex missile should occur prior to system upgrade, it would require the expenditure of many or perhaps nearly

all of the interceptors deployed in Alaska to try to defeat that level of threat. The rule is that all objects (RVs or decoys) that cannot be determined to be a decoy must be treated as a target for destruction. A complex target array would likely have some decoys that could not be resolved. However, once the NMD system is upgraded around 2010, it should be capable of defeating complex target arrays using fewer interceptors. Meanwhile, the effort and resources expended to field the initial NMD capability would not be wasted since it would be a step along the path leading to the advanced NMD capability.

NMD testing. Although most policy makers are focused on the record of hits or misses being produced by the NMD flight-test program, it is the integration of the components and the capability of the system to discriminate the target array that are the more critical challenges needing resolution early in the development effort. In the first two flight tests, the sensors were exposed to target arrays of medium complexity to assess their capabilities to determine the differences between the elements of the array.

The first flight test that attempted an intercept was successful against a simple target array composed of three objects: the booster, a balloon, and the RV. The array incorporated a key discrimination test in that the signatures of the items in the target array had been altered so that the RV was the smallest object in the array and, contrary to the normal signature situation, it was also the coolest object in the sensor's view (rather than the warmest). Although there is some dispute over the success of the mission, the EKV hit the correct target even though a human error

in loading the star map put the EKV off course when it reached the predicted intercept area.

In test four (the second intercept attempt), moisture contaminated one of the cryogenic gasses (krypton) used to pre-cool the IR focal plane. Ice formed, plugging a small opening in a routing pipe preventing the focal plane from being cooled sufficiently for its IR sensor to function. Gradually, the lessons taught by these types of problems will result in product and procedural improvements needed to ensure consistent hit-to-kill success. The more challenging issue is whether or not the EKV can discriminate among the objects in a

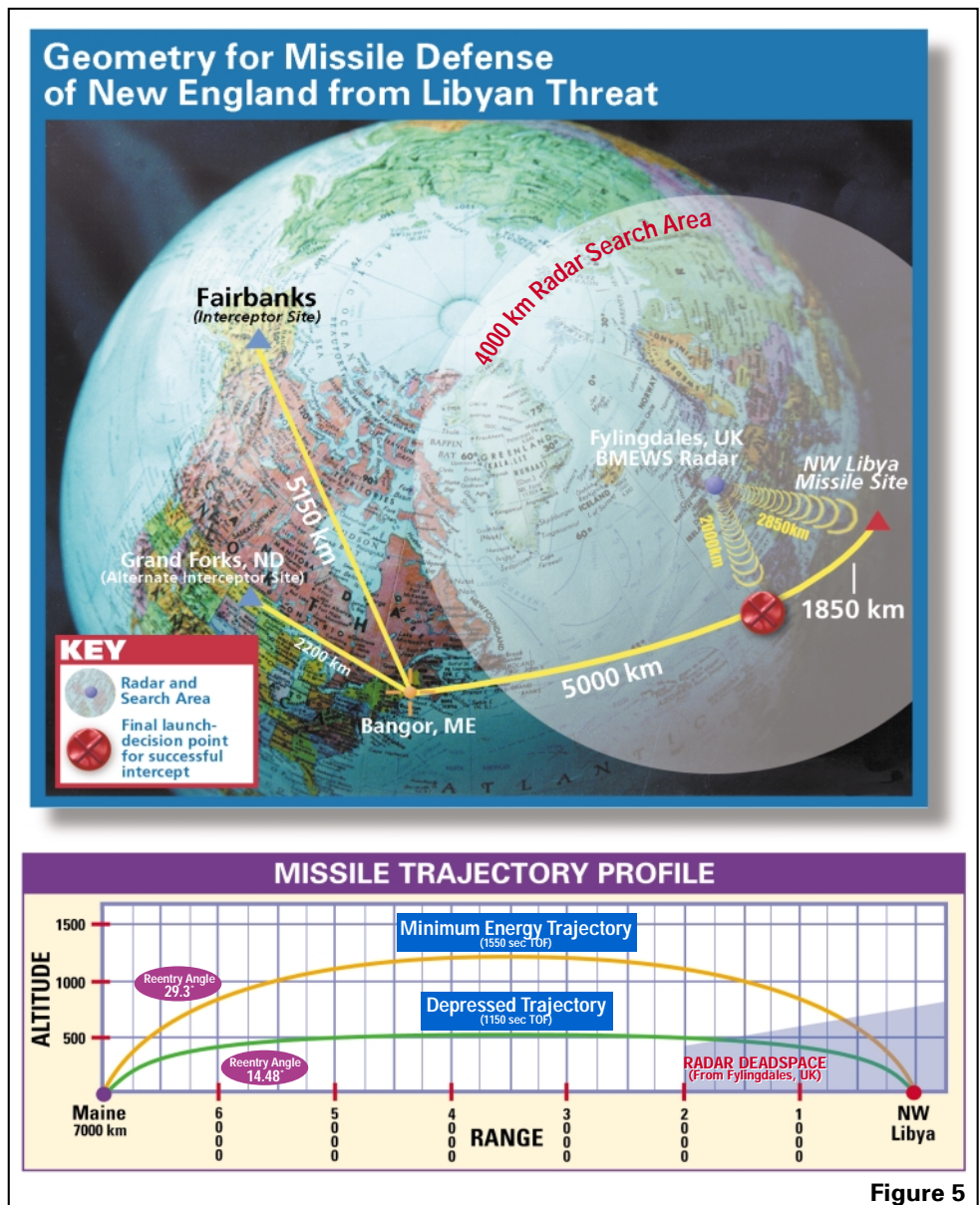


Figure 5

target array consistently. Other challenges associated with the testing program are discussed on pages 4.14 and 4.15.

NMD system capabilities. The initial single-site defense will rely entirely on the EKV for target-array discrimination. Due to the flight distances that will be involved in many of the potential intercept attempts, the battle manager will be forced to use salvo-launch tactics in many of the scenarios examined. For example, a Libyan missile launched toward Bangor, Maine would follow a trajectory 6850 kilometers long. It is 5150 kilometers from Fairbanks to Bangor. Obviously, if the first interceptor missed the Libyan missile, there would not be enough time for a second shot. Thus, four or more interceptors would have to be dispatched in a rippled salvo soon after the

missile's launch was detected. If the first interceptor connected, the follow-on systems would be wasted. A similar situation would exist if a second interceptor site is established at Grand Forks, North Dakota (see figures 5, p. xi, and 6).

If the United States wanted to increase its NMD capabilities, it would need to increase the number of potential engagements that would use shoot-look-shoot tactics. Such tactics would allow the fielded missile force to defeat a greater number of offensive systems than would be the case where salvo-launch tactics are common.

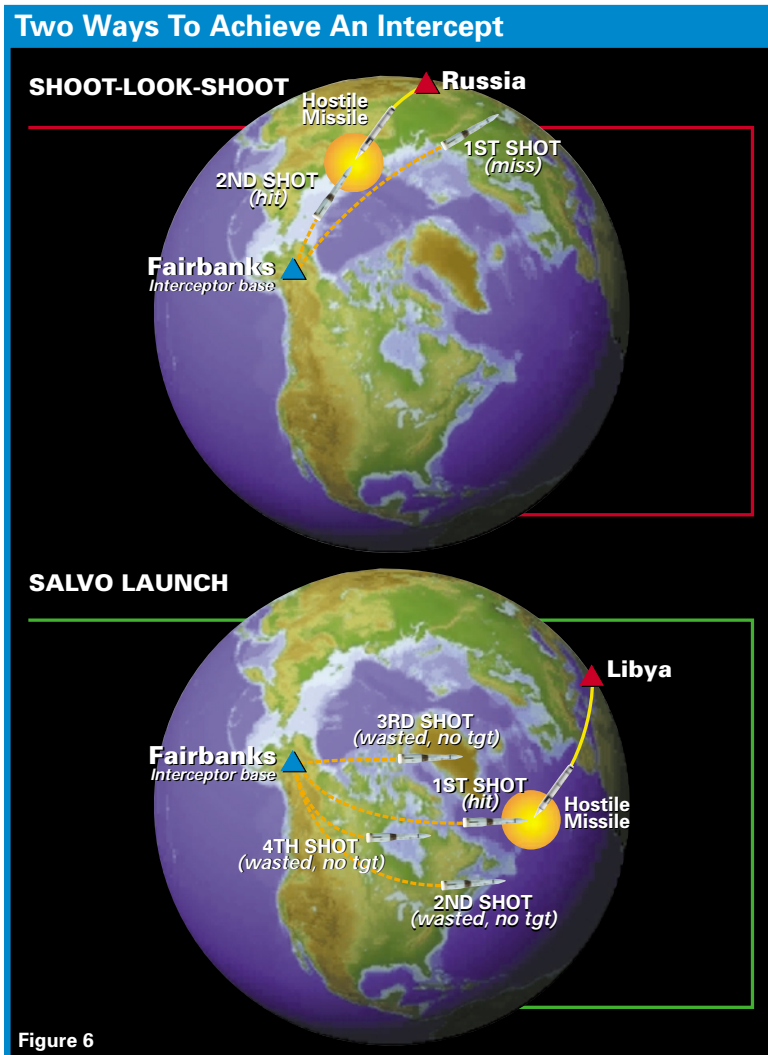
Chapter 5: Alternative NMD Proposals

Three alternative NMD proposals are discussed:

- Boost-phased interceptor for land-basing
- Navy NTW system for use against ICBMs
- Space-based laser (SBL)

Boost-phase intercept. A boost-phase intercept system would attempt to hit the missile while it is still boosting. Current midcourse kill-vehicles cannot target a missile while in boost-phase (the intense IR energy blinds the sensor). It has been proposed that an 8 to 8.5 kilometers per second (kps) missile with a boost-phase-capable seeker be developed for land-based deployment. The proposed system would be able to defend a footprint of 800 to 1000 kilometers (figure 7), thus requiring basing rights in a host country (e.g., Russia, Turkey, or Ukraine).

The potential drawback of such a system is that when the boosting missile is struck, its payload may not be destroyed. In some cases, its payload could fall to earth, possibly detonating in the country hosting the interceptor base. Consequently, it is questionable whether or not many countries would be willing to have such a base on their territory. Although its engagement footprint would be smaller than that of the land-based option discussed in the foregoing (due to the slower flyout velocity of its missile), the possi-



bility of basing such a capability at sea on *Aegis* ships needs to be explored -- discussed in Chapter 6.

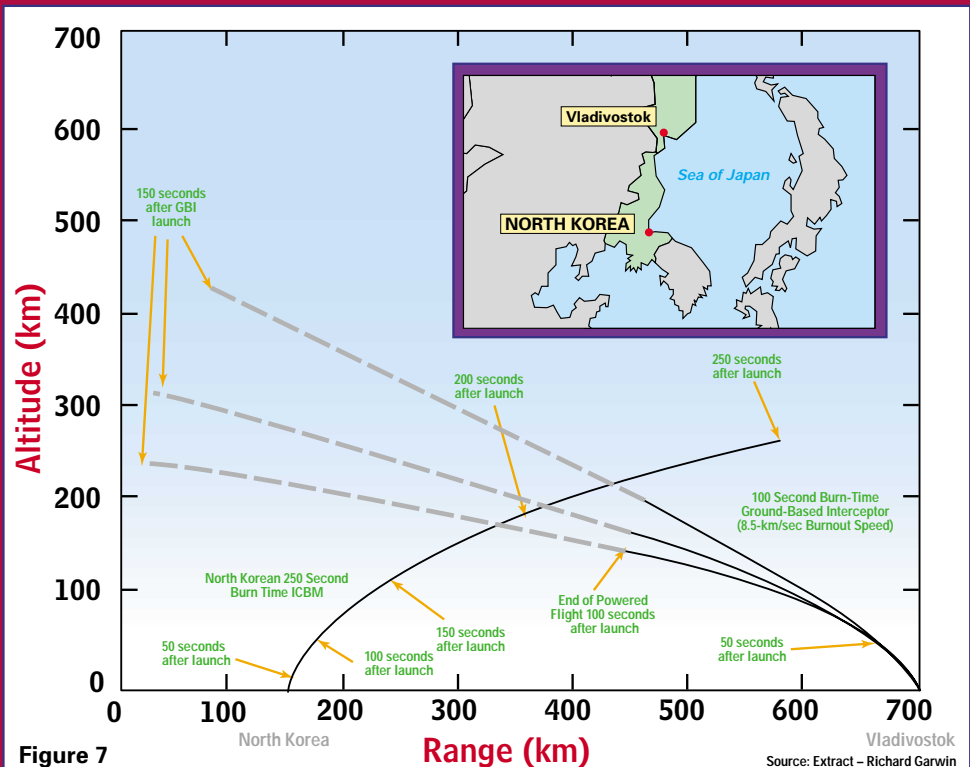
Sea-based NMD system.

Another alternative proposal is that the Navy Theater Wide (NTW) missile defense program be accelerated and substituted for the land-based NMD system. The argument has been used that since a missile-launch system already exists in the navy's *Aegis* ships, the U.S. should capitalize on that sunk investment--a proposal that minimizes the fact that the launch facility is far less important than is the global network of the sensors, processors, and communication assets. In addition, there is still much work that needs to be done before the navy can deploy its NTW Block II capability. Even after its 4.5 kps interceptor is developed, the single-color LEAP kill vehicle (operating at a velocity that is slower than that of ICBM-class missiles) would produce an NMD capability inferior to that being developed for the land-based system. Clearly, the NTW system has great potential for use as an NMD augmentation asset, but inherent limitations prevent its use as a replacement system for the current program without sacrificing missile defense capability (see pages 5.4 to 5.13).

As the navy's Block II NTW system is developed, it should be optimized to perform midcourse ascent-phase intercepts within the limitations of the system. Such a capability could act to thin a missile attack; it would also add an additional capability to discriminate the target array. However, it is clear that such a capability would be location dependent.

SBL. The SBL will provide a global boost-phase intercept capability that should be able to destroy about 80 percent of ballistic-missile

Powered Flight Profiles of North Korean 250 Second Burn-Time ICBM and Russian-US 100 Second Burn-Time Ground-Based Interceptor



threats. Unfortunately, the system is unlikely to be ready for deployment before 2018 because a number of the complex development challenges that must be solved depend upon making some technological breakthroughs, a requirement that makes the program a high-risk project. Although there may be some potential for accelerating this program, the acceleration would probably be measured in terms of a few years rather than a dramatic shortening of the development timeline. The SBL capability clearly should be pursued, but not as a potential option for near-term deployment. Its deployment will also require that policy makers first confront the issue of stationing weapon systems permanently in space.

A layered missile defense. The ultimate U.S. objective should be to establish a layered missile defense. The ability to attack a missile at several points along its flight path creates a synergy among the systems that significantly improves the overall effectiveness of the defense. The Airborne Laser and a boost-phase interceptor

system--and in the more distance future a space-based laser--could be employed to destroy a missile during boost-phase before it deploys its payload. Utilizing *Aegis* cruisers with their inherent advantage of mobility as platforms, the Block II NTW capability can be used to attack ICBMs during their ascent phase of the midcourse (location dependant). The now programmed land-based NMD system should be deployed to handle payloads that are in the descending phase of the midcourse trajectory.

If or when deployed, the space-based laser would provide a highly effective defense against boost-phase missiles, but even with the deployment of that system, the terrestrial missile defense systems will still be required to destroy warhead packages that leak through the SBL's defensive shield. Consequently, the effort expended on terrestrial defenses will not be wasted since they still will be required for decades to come. Although the first priority should be to establish the initial land-based NMD system, the alternative options hold promise for strengthening that defense and further decreasing the vulnerability of the United States to future missile threats. Therefore, they should be viewed not as competing systems but as reinforcing elements of the missile defense that will be needed by the United State in the decades ahead.

Chapter 6: Findings and Recommendations

- Russia and China believe that it is in their interest to undermine U.S. power and raise additional centers of power to help counter U.S. dominance.
- Present trends indicate that Russia will have a net loss in strategic missile capability in the future although it will field an increasing number of new SS-27 ICBMs.
- It is not in the interest of the United States to have Russia or China build new strategic capabilities or increase their rate of missile technology transfers to other states.

- Missile proliferation is spreading around the rimlands of Eurasia. The U.S. and its allies are or will be threatened by this movement unless it is slowed immediately.
- Although bilateral U.S.-Russian arms control agreements provide for the reduction of nuclear arms, they fail to address the problem of third-state proliferation. The ABM treaty, in particular, encourages asymmetrical proliferation activities by making it impossible for the United States to build the kind of missile defense needed to counter new missile threats.
- The land-based NMD program can provide an effective defense sooner than could any of the proposed alternatives. The issue is not the launch platform; the issue is sensors, interceptor velocities, and the global communications and processing network needed for an effective defense.
- The initial NMD system will provide an interim capability against rogue-state missile threats. Just as important, however, is the fact that the initial system provides a structure that can be upgraded as technology becomes available. It is the C2 NMD architecture that would provide the full capability to counter advanced missile threats. (Note: if a deployed NMD system will be as ineffective as its critics claim, why are Russia and China fighting its deployment so vigorously?)

The recommendations are specified on pages 6.10 to 6.14. They contain new ideas for developing a possible consensus on future U.S. security policy and the NMD question. Since these recommendations may be controversial to some, please turn to page 6.10 to read this short section with the accompanying rationale for the five recommendations cited.

Introduction



Although the Cold War has been over for a decade, international relations scholars and U.S. policy makers are still struggling to understand and adjust to the new global structure. The mere fact that the current period is still referred to as the post-Cold War era exemplifies the problem.

A decade ago, many international relations specialists assumed that the unipolar international structure that resulted from the collapse of the Soviet Union would prove to be a temporary aberration, a “unipolar moment”¹ that would soon devolve into an international system with additional power centers. To the bewilderment of many, it is increasingly evident that the international system has settled into a unipolar structure that is expected to last for some time to come.²

A number of states are disgruntled over the unipolar structure and the vast concentration of economic, technological, and military power in the hands of the United States. The clear but unintended lesson of Operation Desert Storm and NATO’s Kosovo bombing campaign, Operation Allied Force, is that the United States is too powerful to be deterred or defeated militarily by conventional means. The implication is that any state

that might someday find itself in a military confrontation with the United States will only attain its objectives if it has some means of deterring the world’s lone remaining superpower from acting, or at least of limiting its scope of action.

This realization has prompted many foreign commentators – official and otherwise – to call for the development of missiles and/or weapons of mass destruction (WMD) to ensure that the United States cannot do to their countries what it did in Iraq and Kosovo, or carry out anti-terrorist operations such as those it undertook in Afghanistan and Sudan (that is, launch missiles and bombs with impunity).³ At the same time other governments, such as those of South Korea, Taiwan, and Egypt, are searching for a means to counter nuclear-armed regional adversaries. Although the rationale varies from country to country, it is now obvious that a significant

¹ Charles Krauthammer, “The Unipolar Moment,” *Foreign Affairs: America and the World* (special edition) 70, no.1, (1999): 23-33.

² For an extensive examination of such theses, see James E. Dougherty and Robert L. Pfaltzgraff, Jr., *Contending Theories of International Relations: A Comprehensive Survey*, 4th ed. (New York: Addison Wesley Longman, 1997), especially 81-89, 118-128. For a good overview of the unipolar issue see William C. Wohlforth, “The Stability of a Unipolar World,” *International Security*, summer 1999, 5-41; and “2000-2010: Can America’s New Golden Age Be Sustained,” *Strategic Forecast’s Decade Forecast*, 21 December 1999, <http://www.stratfor.com>.

³ Many of these commentaries originated in China and India. However, the author found similar references in media reports from other countries as well.

number of states are actively seeking missile and WMD capabilities. Consequently, in a reversal of the Clinton administration's previous position on missile proliferation that denied the extent of the problem, Secretary of Defense Cohen stated at a 20 January 1999 press conference that "We are affirming that there is a growing threat and that it will pose a danger not only to our troops overseas, but also to Americans here at home."⁴

Once the administration acknowledged the growing missile and WMD threat, the focal point of the debate in the United States began shifting from an argument over the extent and seriousness of ballistic missile proliferation to one more focused on what to do about the growing spread of missile and WMD technology. Specifically, the current debate is focusing on three key related aspects of this issue: 1) how to deal with global proliferation, 2) the probable effect that missile defense systems would have on global stability (especially Russian and Chinese reactions) and the arms control legacy of the Cold War era, and 3) the readiness of missile defense technologies to provide an effective defense against current and anticipated ballistic missile threats.

In anticipation that national missile defense (NMD) issues and options will be vigorously debated during the next two years, **this study provides an in-depth examination of the NMD program within the overall context of U.S. requirements for maintaining international strategic stability. Specifically, this study reviews the NMD-related arms control and missile defense policy dichotomies, the evolution and status of NMD program elements, and the major technology issues associated with NMD deployment and future system evolution.**

"Both missile and terrorist threats must be countered if the United States is to enjoy some measure of security in the twenty-first century."

– p. 1.3

NMD and its place in the national security spectrum

An oft-stated opinion is that if a country wants to attack the United States, it can do so by clandestine delivery of a suitcase-sized weapon of mass destruction. It would be foolish to launch a missile at the United States, because the United States would know exactly against whom to retaliate. No country will attack the United States knowing that such an action would result in its own destruction. Consequently, according to this logic, we must ask why the United States needs a national missile defense system.

In the face of these arguments, a short contextual examination of threat motivation is warranted. It is true that **the United States is becoming vulnerable to at least four primary types of attack:**

- **A terrorist-style attack using WMD.** This attack could be delivered in a suitcase, or in a container loaded on a ship as cargo and detonated when the ship reached a U.S. port, or by some other means just as simple. However, when the United States is in a crisis situation such as occurred during Operation Desert Storm, terrorists have found it more difficult than expected to penetrate U.S. borders. Nevertheless, the United States is in the process of preparing for consequence management operations (that is, dealing with the immediate results of WMD terrorist incident, for example, in a major U.S. city).⁵
- **Long-range cruise missile attack,** probably launched from a ship or perhaps from an aircraft. Such a missile launch could be difficult to detect since the missile would fly below U.S. land-based radar coverage. If the missile were detected (perhaps by a space-based or an elevated radar), it could be destroyed if an armed

⁴ U.S. Department of Defense press conference with William S. Cohen, secretary of defense, and Lt. Gen. Lester L. Lyles, director, Ballistic Missile Defense Office, Room 2E781, the Pentagon, 20 January 1999. A summary of the announcement was released by the Office of the Assistant Secretary Defense (Public Affairs), "Cohen Announces Plan to Augment Missile Defense Programs," news release no. 018-99, 20 January 1999.

⁵ For a detailed discussion of consequence management, see two workshop reports by IFPA affiliate National Security Planning Associates, "Homeland Defense," 25 January 1999; and "Military Support To Foreign Consequence Management," 16 July 1998. Also see Richard A. Falkenrath, Robert D. Newman, and Bradley A. Thayer, *America's Achilles Heel: Nuclear, Biological, and Chemical Terrorism and Covert Attack* (Cambridge and London: MIT Press, 1998). For an examination of the problems of terrorist delivery of a WMD system during a crisis see K. Scott McMahon, "Unconventional Nuclear, Biological, and Chemical Weapon Delivery Methods: Whither the Smuggled Bomb," *Comparative Strategy*, 15, 1996, 123-134; See also, Neil King, Jr., and David S. Cloud, "Casting A Global Net, U.S. Security Survived A Rash of Millennial Plots," *The Wall Street Journal*, 8 March 2000, p.1.

interceptor were in the vicinity of the missile's flight path and could be vectored to an intercept point. Moreover, since most cruise missiles have ranges of less than 2000 kilometers (most are limited to 100-200 kilometers), there are still some range limitations on their use during a crisis situation when the United States would be on full alert. Experts expect the cruise missile threat to intensify during the next decade, requiring the United States to take additional defensive steps. It should also be noted that short- or intermediate-range ballistic missiles can be used to attack continental U.S. targets when launched from sea-going platforms.

- **Information warfare (IW) attack.** Essentially, this would be an electronic attack against the United States' computer network, a network vitally important to the U.S. economy. The aim of such an attack would most likely be to cause massive economic damage or to cripple U.S. military operations during a crisis.⁶ It is also becoming increasingly evident that U.S. space-based information systems will be challenged in the future.⁷ While the United States has activated some IW defense organizations to combat the threat of electronic attacks against computer networks, it has yet to address the potential vulnerability of its space assets.
- **Ballistic missile attack or threat of attack.** Such an attack, like an IW attack, can be launched from the territory of the hostile country. Terrorism and ship- or airplane-launched assets require movement of people and equipment against a location in or near the United States, thus providing an opportunity for interdiction. Of each of the threats noted, only the ballistic missile can be launched from a hostile state's territory against which the United States has no possible means of defense, except for the threat of retaliation or preemptive attack operations.

It must be clearly understood that long-range ballistic missiles are primarily national policy tools of deterrence and coercion. States acquire

them for a variety of reasons: to garner international prestige, to coerce policy decisions by other states, or to deter action by foreign powers that might be tempted to intervene in issues of national interest. As tools of national policy, long-range missiles are not expected to be used in the normal course of events and are not in the same category as the WMD systems used clandestinely by terrorists or rogue states engaged in illegal acts of undeclared war. Therefore, the use of one does not preclude the use of another method of attack. Both missile and terrorist threats must be countered if the United States is to enjoy some measure of security in the twenty-first century.

"Assuredly, no country wants to provoke the United States into conducting a retaliatory nuclear strike against its territory. Fools they are not."

– p. 1.3

Accidental or unauthorized missile strike against the United States

Assuredly, no country wants to provoke the United States into conducting a retaliatory nuclear strike against its territory. Fools they are not. However, the possibility that a nuclear state might lose control over one or more of its strategic missile systems and launch a limited unauthorized or accidental strike against U.S. targets seems more probable today than it was during the Cold War. The crumbling nuclear command-and-control system in Russia, the increased danger of internal loss of control, the level of discontent among nuclear crews, and the increasing number of nuclear states that have questionable safeguards against unauthorized use indicate some increase in the level of risk that these missile systems pose. Although the de-targeting agreement between the United States and Russia provides some limited safeguards against unauthorized launch scenarios, it is not a foolproof measure, nor is it verifiable. Missile systems can be retargeted quickly, as undoubtedly they would be in a crisis.

⁶ Reports have circulated in many countries examining the vulnerability of the United States to information warfare. For an example, see "Iranian Journal Examines Electronic Warfare," *Nashriyeh-e Siasi Nezami* (Tehran), 2 February 1999, translated in FBIS-TAC-99-033.

⁷ For an example, see "PLA Said Preparing for Space War," *Ming Pao* (Hong Kong), 26 December 1999, p. B6, translated in FBIS.

The New Strategic Setting



...if a country such as North Korea wanted to coerce U.S. policy or deter U.S. military action, it could threaten any U.S. state it has the capability of striking.

- p. 1.4

The laws of probability suggest that if an unauthorized or accidental launch of an ICBM should occur, the missile's reentry vehicles would most likely be aimed at targets located within the contiguous forty-eight states (since a vast majority of Russian and Chinese strategic missiles are programmed to hit strategic targets in the heartland of the United States). **Thus, most accidentally launched missiles would likely be bolts out of the blue, approaching the forty-eight contiguous states from the northeast, north, or northwest, and without the advance warning that a crisis would provide.**

Strategic and tactical missile strikes against the United States

On the other hand, if a country such as North Korea wanted to coerce U.S. policy or deter U.S. military action, it could threaten any U.S. state it

has the capability of striking. The two U.S. states most vulnerable to a missile strike from north-east Asia because of their geographical locations are Alaska and Hawaii. Unfortunately, if the United States deployed a single-site national missile defense at Grand Forks, North Dakota (as discussed in chapter 2), the states of Alaska and Hawaii would be virtually undefended. Consequently, these two states would be likely hostage candidates for North Korea. In such a situation, a threat against Anchorage or Honolulu would trigger as great a dilemma for U.S. decision makers as one against Omaha.

As we well know, countries such as North Korea, Iran, Libya, and probably Iraq are working to develop long-range missile systems, presumably to deter U.S. intervention in their respective regions or to punish or "bloody" the United States if it should intervene in a regional conflict.⁸ Consequently, if U.S. forces should become engaged in a future regional conflict against an opponent with ICBM assets (such as could occur on the Korean peninsula), that country's leadership could order, or threaten to order, a missile strike against the United States, especially if U.S. forces should begin to win the conflict or attack targets deemed critical to the hostile regime's survival.

Moreover, the mere possession of ICBMs could provide states sponsoring terrorism with a deterrent against large-scale U.S. military reprisal for a terrorist attack (figure 1), diluting the key U.S. deterrent tool for dealing with terrorism. Hence, if a WMD suitcase bomb were delivered, the suspected sponsoring country could use its possession of ICBMs to mute the U.S. response, especially if the country in question had hidden missiles that could not be destroyed by a preemptive or retaliatory strike.

Perhaps more important are the implications of the strategic thinking taking place in some countries on the potential for warfighting nuclear forces. Unfortunately, if states begin to view nuclear weapons as employable, the myth that nuclear systems are unusable will eventually be undermined. Such a trend in strategic thinking raises the possibility that future crises could result in limited or selective missile exchanges at levels lower than mutual assured destruction.

For example, Chinese strategists want to tie China's tactical nuclear missile forces to its strategic deterrent assets (similar to NATO's flexible response doctrine of the Cold War era, MC 14/3).⁹ The strategic nuclear philosophy under discussion in China is well reflected by the often cited 1996 report of a Chinese general telling Ambassador Chas W. Freeman, Jr., that the United States would never be willing to trade Taipei for Los Angeles. Although not yet believed to be official Chinese doctrine, analysts have seen indications

that Chinese strategists have explored the idea of conducting a limited nuclear strike against a U.S. strategic target if the United States should ever conduct a military attack against targets on the Chinese mainland during, for example, a Taiwan Strait conflict.¹⁰

Analysts speculate that China's military thinkers envision that a U.S. nuclear counter-attack would be proportional to the degree warranted by a limited Chinese attack. They might, in fact, believe that they could insure the proportionality of the U.S. response by maintaining an assured second-strike capability (one protected from preemption) that could inflict unacceptable damage on a significant number of important targets in the United States,¹¹ even if the United States delivered a devastating blow to China. The threat of the Chinese second-strike might limit the U.S. response to China's initial use of nuclear weapons.

Their underlying thinking seems to be that the Chinese are more inured to hardship than are the Americans. China, with its 1.2 billion people, is less vulnerable to the threat of losing population. Moreover, China's infrastructure is less developed and therefore provides fewer targets for destruction than does the United States'. While the Chinese obviously do not want to provoke

"The laws of probability suggest that if an unauthorized... launch of an ICBM should occur, the missile...would most likely be aimed at targets located within the 48 contiguous states."

- p. 1.4

⁸ Joseph S. Bermudez, Jr., remarks at the IFPA symposium Exploring Future Missile Defense Requirements, Washington, D.C., 22-23 January 1998. Joseph Bermudez has written extensively on North Korean military capabilities, both for various Jane's publications and as the author of several books, including *The Armed Forces of North Korea* (Sidney: Allen & Unwin, 1999). He is also a contributing author to several books, including *North Korea, Planning the Unthinkable*, ed. James Wirtz, Scott Sagan, and Peter Lavoy (New York: Colombia University Press, forthcoming). During his remarks at the above IFPA symposium, he noted that North Koreans often refer in conversation to the need to "bloody" the United States in retaliation for a successful intervention in any future Korean conflict, an event generally referred to as an after-the-fact strike.

⁹ China's evolving nuclear thinking is extensively discussed and documented in chapter 3 of the study Exploring U.S. Missile Defense Requirements in 2010, Institute for Foreign Policy Analysis, April 1997.

¹⁰ Several articles appeared during 1999 that indicate a growing inclination of the People's Liberation Army (PLA) to use nuclear weapons in a Taiwan Strait conflict. Various publications have discussed the possibility of preempting Taiwan's military concentrations by using a limited nuclear strike and detonating a high-altitude nuclear burst to deliver electromagnetic pulse (EMP) effects. The information is usually attributed to official Chinese sources. For example, see "Great Wall Project Said To Deter Taiwan Independence," *Sing Tao Jih Pao* (Hong Kong), 26 November 1999, p. A17, translated in FBIS; Yoshihisa Furumori, "Signs of Change in China's Nuclear Strategies," *Sankei Shimbun* (Tokyo), 6 August 1999 (Internet version), translated in FBIS; and Hoa Tien, "Thorough Disclosure of the Inside Story of Chinese Military Maneuvers," *Hong Kong Kuang Chiao Ching* (Hong Kong), 16 October 1999, pp. 51-53, translated in FBIS. Of course, the possibility that such statements are part of China's psychological game plan for keeping Taiwan uncertain of possible PRC reactions to Taiwan's independence movement must also be considered.

¹¹ For some other well-documented and insightful reading on this issue, see Alistair Iain Johnson, "China's New Old Thinking: The Concept of Limited Deterrence," *International Security* (winter 1995-96): 28. For a recent update of China's doctrinal development, see Ehsan Ahrari, "China Changes Its Strategic Mindset, Part One," *Jane's Intelligence Review* (November 1999): 39-44, and Ehsan Ahrari, "China Changes Its Strategic Mindset, Part Two," *Jane's Intelligence Review*, December 1999, 30-35.

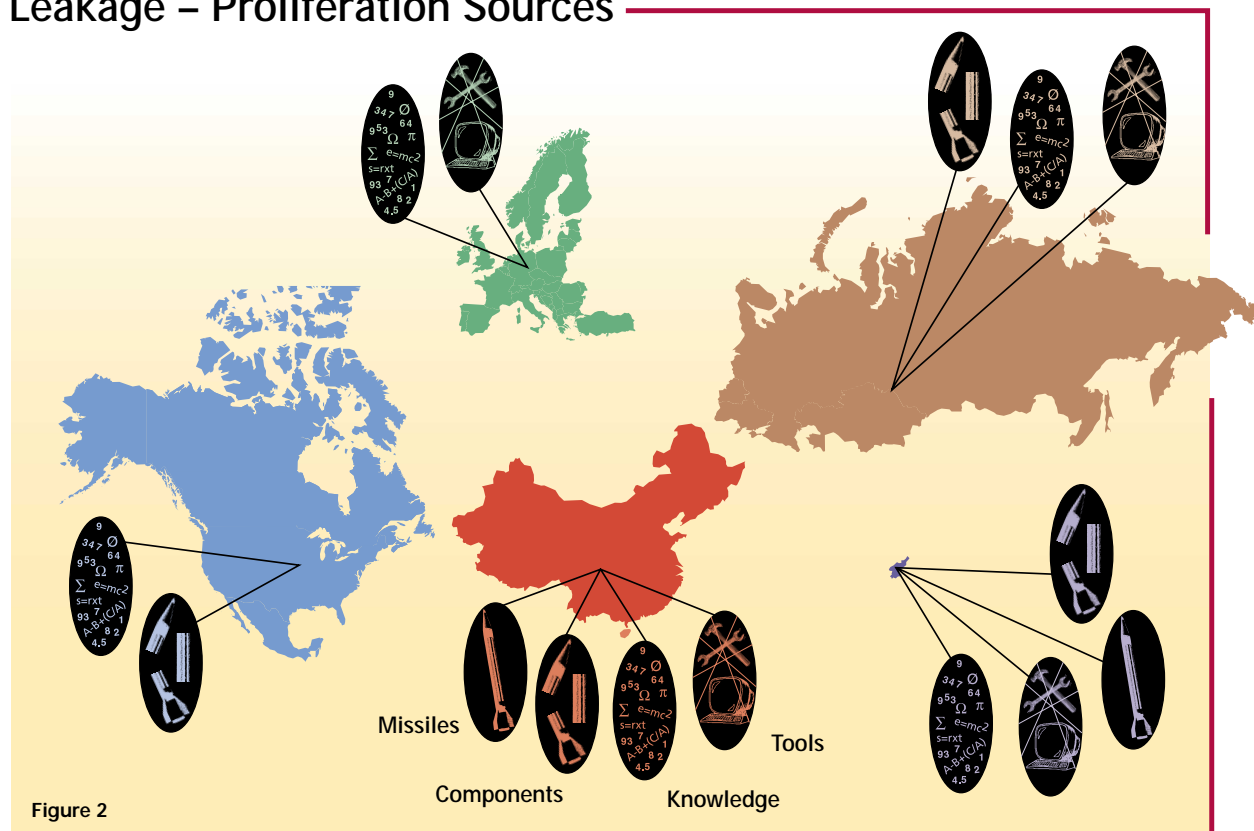
the United States into annihilating their country, they also seem to believe that if it came to a nuclear showdown, they, as the more determined people, would win. Essentially, the Chinese appear still to have the perception that the United States would prove a paper tiger if America itself were threatened, that a Chinese willingness to use nuclear weapons would win the confrontation without ever having actually to use the nuclear option – a classic application of Sun Tzu's military philosophy.¹²

When we examine this perspective in light of China's ongoing efforts to develop a more robust second- and third-strike capability (discussed later), the United States must question China's future intentions, along with those of other states that seem to be moving in the same direction. The real challenge is how to alter China's direction without increasing tension levels or unnecessarily creating an enemy state.

The International Security Situation and the Developing Missile Threat

The actions and motivations of the major players in the current proliferation drama need to be understood if the United States is to take effective action to counter the situation. Since the nature of the growing ballistic missile threat was exhaustively set forth in IFPA's April 1997 comprehensive study entitled *Exploring U.S. Missile Defense Requirements in 2010*, further detailed in July 1998 by the Commission to Assess the Ballistic Missile Threat to the United States (commonly called the Rumsfeld Commission), and officially stated by the 1999 National Intelligence Estimate (NIE), this short threat summary should be seen as an abbreviated review and update of these reports. It simply highlights general international security trends as they are currently understood,

Leakage – Proliferation Sources



¹² For a broader discussion of this point, see David Smith, "Sun Tzu and the Modern Art of Counter Missile Defence," *Jane's Intelligence Review*, January 2000, 35-39.

thereby providing a current benchmark against which to review the U.S. NMD program.

The missile and WMD proliferation snowball is clearly rolling downhill and gathering momentum as more states join the movement, either to achieve some strategic advantage, or as part of a defensive reaction against a neighboring state's proliferation activities.¹³ Much of the proliferation impetus is being fueled by international transfers of sensitive technologies. Unfortunately, as the number of states developing missile and WMD capabilities increases, so does the number of potential suppliers to other would-be WMD states.

All proliferation efforts include strategies for securing needed technology, tooling, parts, critical components, or entire missile systems from states already possessing those capabilities. Although some missile and WMD-related components and technologies have flowed to other states from the United States, Europe, South America, South Africa, and Israel, the vast majority of leakage has come from Russia, China, and North Korea (see figure 2). Unless this flow can be slowed significantly, missile proliferation rates will continue to accelerate and the nonproliferation regimes of the Cold War era will continue to crumble.

Russia

Unfortunately, the Russian Federation has taken a painful economic thrashing, its political cohesion is under pressure, crime and corruption pervade the country, and its military capabilities are in decline. At the same time, anti-Western and, especially, anti-American sentiment is increasing as Russians commonly blame the United States for failing to do enough to help their country make the transition from the Soviet command economy to an economically prosperous, Westernized system. Exacerbating Russian discontent is the expansion of NATO's border eastward, the U.S. bombing of Iraq and Serbia despite Russian objections, and innumerable other reminders that Russia today has little international prestige.

Many Russians appear to view the West's activities through a xenophobic lens that sees all unfavorable foreign actions as part of a conspiracy to destroy Russia.

Within the above limitations, Russian policy makers are clearly working to preserve or restore as much of the former Soviet Union's power and international prestige as possible, hoping to create the conditions necessary to stabilize Russia internally and make the country once again an entity to be reckoned with internationally. Although the prognosis does not look favorable for Russia, it is impossible to predict with certainty the likely success of their efforts, as no one can foresee the future course of Russia's democratic experiment.

In a recent IFPA study, *Strategic Paradigms 2025: U.S. Security Planning for a New Era*, at least four alternative futures for Russia were identified.¹⁴ These spanned the spectrum from the development of a more economically prosperous, and potentially cooperative, Russia to the re-emergence of a staunchly anti-Western, autocratic state. Other scenarios, including the potential for the outright fragmentation of Russia itself and the emergence of multiple state and non-state actors on the territory of the Russian Federation must also be considered. There is also the potential for Russia to muddle along as it has done since the collapse of the Soviet Union, with an ever increasing growth in the influence of criminal elements in Russian society, a steady decline in conventional military capabilities, and little in the way of genuine economic reform.

Strategic Paradigms 2025 concludes that regardless of which scenario comes closest to representing Russia's actual future, we can safely expect that Moscow will work – to the extent

Unless this flow can be slowed significantly, missile proliferation rates will continue to accelerate and the nonproliferation regimes of the Cold War era will continue to crumble.

– p. 1.7

¹³ For a good overview of the nonproliferation problem, see Michael Barletta and Amy Sands, eds., "Nonproliferation Regimes At Risk," *Occasional Papers*, no. 3, Center for Nonproliferation Studies, fall 1999, www.cns.miis.edu/pubs/opapers/ops3.

¹⁴ For a full discussion of what these potential futures might look like, see Jacquelyn K. Davis and Michael J. Sweeney, *Strategic Paradigms 2025: U.S. Security Planning for a New Era's Future*, see 52-70.

its means permit – to protect Russia’s perceived security interests and to assert Russia’s role as a great power on the world stage. Though Russia’s level of cooperation with the West may vary over the next ten to twenty years depending upon on a number of factors – including its own stability and its perception of the degree of threat from other states, such as China – Russia is unlikely to be the close partner some had envisioned in the immediate wake of the Cold War.

Russia’s declared policy is to work toward the establishment of a new world order, one with a multipolar international structure.

p. 1.8

Similarly, the analytical group Strategic Forecast, Inc., of Austin, Texas, projects that Russia is likely to revert to a more centralized form of government in the near term, perhaps one somewhat similar in form to that practiced during the latter years of the glasnost period under Gorbachev.¹⁵ President Putin seems to be trying to move Russia in this direction. Strategic Forecast also warns of a growing possibility that Russia could follow its historical pattern and conduct a bloody cleansing of its criminal elements and the oligarchy class, eventually reemerging as a major power a generation or two in the future.¹⁶

At this point, however, it is not clear that a power base exists that a dictatorial leader could exploit to generate sufficient support to sustain a bloody purge in Russia. Today, the military, the Federal Security Service, the communist party, the government, and most industries have all been infiltrated by criminal elements. Thus, considering the unsettled state of affairs in Russia, no one should be very surprised at whatever direction Russia might take in the future. Under any of these scenarios, the Russia of tomorrow will probably be more anti-Western than was the case during the 1990s.

Externally, Russia’s elites are clearly unhappy with their country’s loss of international stature, and its policy makers understand that for the country to gain more leverage in the international arena, the current unipolar structure must change. Consequently, Russia’s declared policy is to work toward the establishment of a new world order, one with a multipolar international structure.¹⁷ The clear implications of such a policy are that 1) U.S. security must be

weakened and 2) additional power centers must be raised in the international structure. Russia’s actions in providing missile technology and/or other military assistance to China, India, Iran, Iraq, Syria, Libya, and others, along with its efforts to use bilateral arms control agreements to limit U.S. power, are consistent with its stated multipolar policy objectives.¹⁸

Although some of Russia’s missile technology exports can be blamed on illegal smuggling operations, it is also clear that, at a minimum, the Russian government has acquiesced to such actions by failing to enforce export controls or effectively punish those caught shipping restricted technologies or missile components abroad. It is difficult to gauge the extent to which Russia’s actions are being driven by the sheer economic need to preserve defense industries (since it cannot maintain its defense industrial base on the currently depressed defense budget), or its desire to promote the development of a multipolar world. In reality, there is reason to believe that both motives are operating in Russia today.

Russia’s conventional forces are in a poor state of readiness; the country has learned from its Chechnya operations that more resources must be devoted to conventional force readiness. Yet

¹⁵ For a recent review of Russia’s internal situation, see “Russia 2000,” *Strategic Forecast, Inc.*, November 1999, www.stratfor.com.

¹⁶ For an analysis of Russia’s potential to go through a bloody cleansing, see “Russia,” *Strategic Forecast, Inc.*, 23 December 1999, www.stratfor.com.

¹⁷ Both Russian and Chinese officials have made numerous public statements on this policy. Two good examples are “Russian-Chinese Joint Declaration on a Multipolar World and of a New International Order,” *Rossiiskije vesti*, 25 April 1997, p.2, translated in *Current Digest of Post-Soviet Press* 49, no. 17 (28 May 1997): 2; and “Yeltsin, Jiang Agree to Strengthen Strategic Partnership,” *Kyodo* (Tokyo), 25 August 1999, translated in FBIS.

¹⁸ The extent of Russia’s efforts in proliferating missiles and other advanced military technology has become common knowledge over the last couple of years. IFPA’s 1997 study, *Exploring U.S. Missile Requirements*, and the Rumsfeld Commission both provided extensive details on the problem. The 1999 U.S. National Intelligence Estimate reaffirmed that Russia is a major international supplier of missile technology.

even the strategic nuclear forces, presently representing Russia's highest military priority, are starved for resources, to include its nuclear command and control system.¹⁹

Missile production

A large proportion of the Soviet Union's missile production capacity was located in Ukraine. With an independent Ukraine, Russia's residual missile production capacity is significantly less than that of the Soviet Empire's. As a result, Russia has been working to streamline its ballistic missile requirements. It intends to standardize all of its long-range missile systems on the *Topol M* (SS-27) design. The single-warhead missile was conceived during the mid-1980s as the Soviet Union's counter to President Reagan's Strategic Defense Initiative. It has a fast flyout velocity, carries advanced penetration aids (penaids), and maneuvers horizontally during the midcourse of its trajectory to confuse missile defenses. (See figure 3.)

Although Russia has established an objective of producing 30 to 40 SS-27 missiles annually, it has been struggling to field just 10 a year. Even if Russia reached a production level of 30 missiles per year, only 300 systems could be built in a decade. Furthermore, some of the missiles produced would be used for testing, further reducing the quantity on hand.

The current fleet of Russian SS-18, SS-19, and SS-25 ICBMs is aging, with 72 percent of Russia's ICBMs now beyond their factory warranty period.²⁰ However, Russia's missiles still have years of potential use, as the factory warranty period is much like the new-car five-year, 50,000 mile warranty common in the United States. Once the warranty period is over, years of useful life remain, but maintenance requirements and costs generally increase as more parts begin to fail.

Unfortunately for Russia, this means that the problem of keeping its missile fleet operational becomes increasingly demanding as maintenance requirements grow. Because few resources are available for maintenance and a significant proportion of the original missile repair-part production facilities for the heavy SS-18 and some components of other missile systems are situ-



Figure 3

ated in Ukraine, Russia will likely experience some stress keeping its missile fleet operational. Consequently, it is projected that Russia's current force of 756 ICBMs will decline in number as existing missiles are scrapped and production rates of new missiles remain low relative to Cold War levels.²¹ In 1998-99, Russia conducted extensive missile flight tests to validate its aging strategic systems with an expectation of keeping them on active duty until at least 2007.

Nuclear ballistic missile submarines

Russia's nuclear ballistic missile submarine force is in decline²², sharing the fate of Russia's naval

¹⁹ For a sobering look at the condition of Russia's military machine, see Bruce Blair and Clifford Gaddy, "Russia's Aging War Machine: Economic Weakness and the Nuclear Threat," *Brookings Review*, summer 1999, 10-13. For some examples of potential threats due to command and control issues see Peter V. Pry, *War Scare: Russia and American on the Brink* (Westport, CT: Praeger, 1999).

²⁰ Pavel Sheremet, "Live Studio Interview With Col. Gen. Vladimir Yakovlev," *Vremya* newscast, Russian Public Television First Channel, 18 December 1999, translated in FBIS.

²¹ 1999 U.S. National Intelligence Estimate; and Mikhail Nogov, "Russia's ICBM Control Center Profiled," *Rossiyskaya Gazeta* (Moscow), 26 November 1999, p. 6, translated in FBIS. For an exhaustive analysis of the issue (although the naval section is somewhat dated), see Dean A. Wilkening, "The Evolution of Russia's Strategic Nuclear Force," Center for International Security and Arms, Stanford University, July 1998.

²² Tatyana Tsipliyayeva, "Nuclear Submarine Construction at Standstill," *Moscow Center TV*, 5 December 1999, 11:00 a.m., GMT, translated in FBIS.

forces in general.²³ Although Russia's strategic plan reportedly calls for maintaining 55 percent of the country's strike capacity on nuclear submarines,²⁴ many of its missile-launching boats are at the end of their expected service life and are being retired. It has been decided to keep the *Delta III* submarines in the Pacific fleet, modernize them, and extend their operational life to at least 2005. At the same time, it appears unlikely that the first *Borey*-class replacement submarine will be deployed before 2006 at the earliest.²⁵ Upon deployment, plans call for it to be equipped with a new missile, called the *Bulava*. The *Bulava* will incorporate SS-27 ICBM technology reengineered to fit on a nuclear submarine.²⁶ However, much work still needs to be done on the *Bulava* missile program before it will be ready for production.

Of all the services, Russia's naval forces are currently thought to be last in priority for funding. The general staff has long been uncomfortable with strategic missile submarines because they are viewed as difficult nuclear command-and-control challenges as well as vulnerable to U.S. anti-submarine warfare capabilities. It is therefore likely that in the ongoing defense budget squeeze, Russia will continue to give few resources to naval programs. Therefore, the prognosis for the submarine missile fleet is one of steady decline.

Reliance on nuclear capabilities

As its conventional military capabilities have deteriorated, Russia has increasingly emphasized nuclear capabilities in its military doctrines, for both strategic and tactical nuclear systems. Russia's national security will continue to rest on its aging nuclear arsenal for the next ten to twenty years. Russian leaders have announced

that Russia is prepared to use nuclear weapons first if this is deemed necessary to protect its vital national interests.²⁷ Barring a miraculous revitalization of Russia's economic and political systems, its overall military capacity will continue to diminish over the next decade or so; land-based strategic nuclear weapons, although reduced in number, will remain the most critical component of Russia's national security strategy. At the same time, Russia is expected to maintain a robust tactical nuclear weapons capability for the defense of its national territory.

Despite Russia's reduced military capabilities, it will remain in a position to inflict more damage on the United States than any other state, including China, over the foreseeable future.

China

China is struggling to emerge as a great power with a modern economy. Like Russia, it has significant problems with political corruption, cronyism, and economic inefficiencies. Its communist leaders are trying to walk the tightrope of developing a market economy while retaining their legitimacy as the rulers of China. The resulting upheaval of China's economic and political systems has increased the level of social instability.

China's national goals include some contradictory ones that add a special sense of unpredictability to U.S.-China relations. The assessed Chinese goals of greatest interest to this study are:²⁸

- **International status.** China clearly desires the international and regional status and prestige of a great power, one that has international influence commensurate with its population,

²³ Ilya Bulavinov and Ivan Safronov, "No New Ships for Russian Navy Before 2008," *Kommersant* (Moscow), 24 November 1999, p. 3, translated in FBIS.

²⁴ Alexander Kononov, "Russia To Continue Upgrading Nuclear Deterrence Forces," RIA (Moscow), 23 November 1999 transcribed in FBIS.

²⁵ Ilya Bulavinov, "Russia Has No Worthy Response to NMD," *Kommersant* (Moscow), 18 November 1999, p.2, translated in FBIS.

²⁶ Ibid.; Sergey Grigoryev, "CINC Yakovlev Interviewed on 40th Anniversary of RVSN," *Nezavisimoye Voyennoye Obozreniye*, no. 49, 17 December 1999, pp. 1, 3, translated in FBIS; and conversation with Russian military affairs expert Steven Zaloga, November 1999.

²⁷ "Russian Doctrine Allows Some Nuclear Arms Use," Interfax (Moscow), 7 October 1999, transcribed in FBIS; and "Xinhua Reports Russian Doctrine Allows First Use of Nukes," *Xinhua* (Beijing), 17 October 1999, transcribed in FBIS. Russia's published draft military doctrine, which is apparently being used today, provides for Russian use of nuclear weapons in response to the use of nuclear or other WMD systems against Russia or its allies, or in response to large-scale aggression using conventional weapons in situations critical to the national security of the Russian Federation and/or its allies. Thus, Russia is moving toward a much more aggressive nuclear posture than in the past. See Grigoryev, "CINC Yakovlev Interviewed on 40th Anniversary of RVSN."

²⁸ The national goals ascribed to China in this study are also stated (more broadly) in U.S. Department of Defense, "Future Military Capabilities and Strategy of the People's Republic of China," report to Congress pursuant to Section 1226 of the FY98 National Defense Authorization Act, 1998, 1.

ancient culture, and nuclear status. Unfortunately, China is also a country with a chip on its shoulder. It is resentful of its 150-year history of Western imperialistic domination, a humiliation that its leaders vow China will never endure again. Thus, China automatically resists outside political pressure. The result of this combination is a very prickly state highly sensitive to perceived slights.

- **Economic development.** China is trying once again to make the “great leap forward.” It is attempting to adapt the Japanese economic model of 1950 to 1980, of acquiring the latest Western technology and using it to bypass the steps normally required for a country to evolve into a technologically modern society. Thus, China buys, borrows, steals, or uses any other avenue available to acquire the means necessary to emerge as a modern nation within the next fifteen to twenty years.
- **Chinese unity.** Chinese leaders are committed to national unification. Although China has regained control of Hong Kong and Macao by peaceful means, it has not abandoned the option of using military force to gain control of Taiwan,²⁹ thus creating a potentially dangerous situation for the United States in light of Taiwan’s movement toward total rejection of China’s claim to the island.³⁰
- **Energy security.** China has low quantities of known petroleum reserves within its borders. As its economy continues to grow, its dependence on outside supply lines is increasing. Consequently, China has developed close relations with major oil-producing nations while reinforcing its South China Sea territorial claims (Spratly Islands) through military deployments. Its activities in the South China Sea have raised fears in Southeast Asia that China may use military might rather than diplomacy to secure the suspected undersea oil reserves in the region.

Much of China’s conventional military capability is obsolete by Western standards; China is also limited in its ability to project power much beyond its borders. Perhaps China’s most notable military modernization achievements to date lie in the field of missile development. Even though China began modernizing its missile forces in the mid-1980s, it was not until it analyzed the lessons of Operation Desert Storm that its decision makers came to appreciate the value of long-range precision strike capabilities, a lesson that provided greater impetus to China’s missile development efforts. The lesson of Desert Storm was further reinforced by the Kosovo bombing campaign of 1999, when the Chinese took note that the West intervened in Kosovo with long-range precision strike weapon systems over the issue of internal human rights abuses, a sensitive subject with China’s leadership.

Missile development

It is clear that China is on the path to developing a more effective long-range strike capability over the course of the next decade. Much of China’s new long-range missile capability is expected to be mounted on mobile transport systems or kept in underground facilities as a safeguard against destruction by preemptive strike. Its expanded strategic missile capabilities could provide China with some sense of freedom to threaten to use, or actually to use, the many hundreds of tactical ballistic missiles that it is projected to have in its military inventory by 2005 (figure 4, p. 1.12).³¹

China’s reported acquisition of U.S. design information for at least seven types of thermonuclear weapons³² (including the newest, the W88), and China’s apparent successful underground testing of a miniaturized strategic nuclear system during the early 1990s, enables the development of multiple-reentry-vehicle warheads

²⁹ For an insightful summary of PRC public statements on the issue, see Ren Huiwen, “Article Reviews Using Force Against Taiwan,” *Hong Kong Hsin Pao*, 6 August 1999, p. 21, translated in FBIS.

³⁰ Chas. W. Freeman, Jr., “Preventing War in the Taiwan Strait,” *Foreign Affairs* 77, no. 4 (July/August 1998): 6. See also President Lee Teng-hui, “Understanding Taiwan,” *Foreign Affairs* 78, no. 1 (November/December 1999): 7-14.

³¹ Bill Gertz, “China Moves Missiles in Direction of Taiwan,” *Washington Times*, February 1999.

³² U.S. House, *Report of the Select Committee on U.S. National Security and Military/Commercial Concerns with the Peoples Republic of China*, 106th Cong., 1st sess. (May 1999), 60.

China's Military Outlook

Mao: The Inferior Can Defeat The Superior

- China has a "chip" on its shoulder over past western domination of its country. Chinese leaders vow "Never again!"
- Obsolete military with emerging pockets of excellence. Chinese philosophy is to use surprise and pressure points to gain "acupuncture" victory
- Missiles, nuclear weapons, and selected advanced systems are being developed for asymmetrical use
- Figures on right show Chinese thinking on how EMP & effects might be used to cripple & Taiwan's electronic infrastructure
- China does not necessarily agree that nuclear weapons are unusable

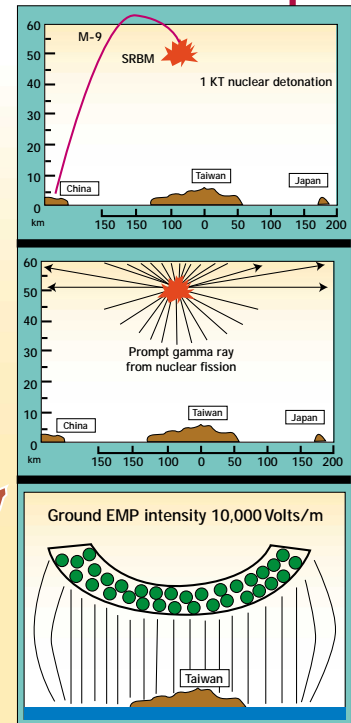
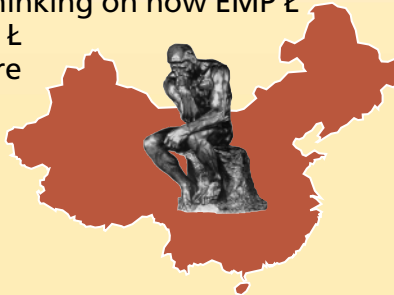


Figure 4

(MIRV).³³ In fact, it is generally understood that China is equipping its future missile systems with MIRVed warheads.

China's long-range strategic missile capabilities during the next decade will be composed of four systems:

DF-5A. This deployed liquid-fueled ICBM has a range of 13,000-plus kilometers carrying a 3200-kilogram payload. China may now be in the process of replacing its single 3- 5-megaton warhead with a new, MIRVed payload.³⁴ The new warhead almost certainly includes missile defense penetration aids (penaids). At least

23 to 26 of these missiles are reported to be deployed; however, controversy has long existed over whether or not more of these missiles are being held in a non-alert status for use as second-strike retaliatory systems.³⁵

DF-31. This new solid-fueled mobile missile is believed to be in the process of being fielded. It has a range of 8,000-plus kilometers, carrying at least a 700-kilogram payload. It may carry up to three reentry vehicles (RVs), or one RV and two decoys. Reportedly, one Chinese test showed a RV and two rigid decoys following separate trajectories (indicating a MIRV capability).³⁶ Three DF-31 launch vehicles were featured in

³³ James Risen and Jeff Gerth, "China Stole Nuclear Secrets From Los Alamos, U.S. Officials Say," *New York Times*, 6 March 1999, p. 1; and James Risen and Jeff Gerth, "China Is Installing A Warhead Said To Be Based On U.S. Secrets," *New York Times*, 14 May 1999, pp. A1, A10.

³⁴ The information presented here on MIRVs has been collected from many sources. The most forthright statement is attributed to General Habiger. "China Building Nuclear Warheads That Could Hit US," *Agence France Presse*, 1 April 1998. His statement makes it clear that the MIRVs are being developed, but his particular comments are less clear that the system to be MIRVed is the DF-5A. See also a report in a PLA-owned paper, which claims that the new DF-25 tactical missile has MIRV capability, "China Test-Fires New Missile," *Wen Wei Po* (Hong Kong), 3 August 1999, p. A1, translated in FBIS. The article also claims that the front two stages (stages 2 and 3) of the new DF-31 ICBM are similar to the two-staged DF-25, which reportedly carries a 2000-kilogram warhead.

³⁵ For some hints at this capability, see "Great Wall Project Said To Deter Taiwan Independence," Zhang Jiajun, Zhang Xuanjie, and Guo Jia, "Newsletter on PRC Strategic Missile Forces," *Xinhua Domestic Service* (Beijing), 11 September 1999, translated in FBIS; Xu Zuzhi, "China's Strategic Missile Unit Now Possesses Fighting Capability Under High-Tech Conditions," *Zhongguo Xinwen She* (Beijing), 1 October 1999, translated in FBIS; Zhang Jiajun and Doug Jianchang, "Study of Strategic Missile Combat Position Troop Survival Under Nuclear Conditions and Development of an Equipment Safeguard System," *Keji Ribao* (Beijing), 18 November 1997, p. 1, translated in FBIS; and Institute for Foreign Policy Analysis, *Exploring U.S. Missile Defense Requirements in 2010*.

³⁶ Bill Gertz, "China Tests New Long-Range Missile," *Washington Times*, 3 August 1999, pp. A1, A10; and Bill Gertz, "Chinese Decoy Warheads Designed to Beat Defenses," *Washington Times*, 16 September 1999, p. A1.

Beijing's fiftieth-anniversary parade on 1 October 1999; the number of systems planned for procurement is unknown.

JL-2. This is the 8000-kilometer range naval version of the DF-31 missile (a recent unconfirmed report claims the range is actually 12,000 kilometers).³⁷ Sixteen JL-2s will be placed on each of China's new Type 094 nuclear missile-launching submarines, the first of which is expected to join China's naval fleet by 2005.³⁸ Analysts project that China will build up to six Type 094 submarines over the next ten to fifteen years, carrying a total of 96 JL-2 missiles. Although many Western analysts believed the JL-2 might carry three reentry vehicles, an unsubstantiated report in a reputable Hong Kong paper claims that the JL-2 will be equipped with six RVs, that a total of 572 warheads are planned for deployment with the completed Type 094 submarine force.³⁹ Regardless of the exact numbers involved, it is clear that China will have a significant missile capability on its new nuclear submarine force once it is deployed.

DF-41. This will be a new solid-fueled missile similar to the DF-31 but larger. Analysts expect it to have a range of 12,000-plus kilometers carrying a 2,000-kilogram payload. It is expected to be MIRVed, possibly having a payload of as many

as ten RVs, and to be equipped with advanced pen aids. It might begin deployment between 2002 and 2004.

No certainty exists regarding the number of strategic warheads China intends to build as it modernizes. Russian reports indicate that China's objective is to field approximately the same number of long-range missile systems as it formerly had in mixed-range, land-based systems (approximately 100 missiles). Under this supposition, if the DF-31s and JL-2s carried three RVs each and the DF-41s carried eight or nine, it is plausible that China could have 400 to 600 nuclear warheads capable of striking the United States by 2015. If, however, the JL-2 carries six RVs, the estimates would be higher by at least 200 warheads. Moreover, since China has about four tons of weapons-grade plutonium (plus or minus two tons) and 15 to 25 tons of Uranium-235,⁴⁰ it is capable of producing several thousand nuclear warheads using the miniaturization technology it may have stolen from the United States. Thus, China could field considerably more than 100 long-range MIRVed missiles if it so chooses.

China's stand on unipolarity

Like Russia, China's leaders are unhappy with the current unipolar international structure. China formally joined Russia in 1997 in issuing a joint declaration to "make efforts to further the development of a multipolar world...." This policy was reiterated when the Presidents of the two countries met in August 1999,⁴¹ and again



DF-5



DF-31

³⁷ Bill Gertz, "U.S. Secrets Aboard Latest Chinese Sub," *Washington Times*, 6 December 1999, p. A9.

³⁸ Paul Beaver, "China Flexes Muscles in Missile Exercise," *Jane's Defence Weekly*, 4 August 1999, 5.

³⁹ "New Nuclear Submarines To Be Launched by Year 2002," *Ming Pao* (Hong Kong), 8 December 1999, p. B17, translated in FBIS. Note that this article claimed the first submarine would be launched in 2002, which differs from U.S. projections of 2005. Some of the difference may be attributed to the time needed for sea trials and integration of the missile system with the boat. It is likely that the 2005 date is the timeframe when the system will be on routine patrol.

⁴⁰ Conversation with David Albright, Institute for Science and International Security, 27 October 1999. Dr. Albright is a specialist in international fissile material stockpile levels.

⁴¹ "Russian-Chinese Joint Declaration on a Multipolar World and of a New International Order," *Rossiiskiy vestnik* (Moscow), 25 April 1997, p.2 translated in *Current Digest of Post-Soviet Press* 49, no. 17 (28 May 1997): 2; and "Yeltsin, Jiang Agree to Strengthen Strategic Partnership," *Kyodo* (Tokyo), 25 August 1999, translated in FBIS.

in November 1999.⁴² Chinese actions suggest that their multipolar efforts include proliferation of missile capabilities to other states. Numerous

North Korea, Iran, Pakistan, Syria, Libya, Iraq, and other states are also putting their key missile production facilities underground, thereby complicating U.S. intelligence collection efforts...

p. 1.14

reports claim that China has provided missiles or missile development assistance to such states as North Korea, Pakistan, Iran, Syria, and Saudi Arabia. Although some of this help may come from industries and corrupt elites seeking personal gain, the amount of proliferation activity suggests government acquiescence or sponsorship.

Although China is benefiting from the stabilizing effect of the U.S. presence in East Asia, Chinese leaders clearly believe that it is in their country's long-term interest for U.S. power to diminish. Thus, the United States should anticipate that China will continue to support activities designed to counter or weaken the United States, including opposition to U.S. national missile defense programs as well as to U.S. efforts to provide missile defense capabilities to its allies.

North Korea

North Korea is a highly militarized state struggling for survival. Its command economy is in serious trouble, yet few reforms have been enacted. The country has few viable exports other than gold, and military equipment, and drugs. Considering the depressed state of global gold prices, which limits the amount of foreign exchange North Korea can earn from gold sales (a trend likely to continue, as Britain is in the process of selling up to half of its gold stocks), North Korea's sale of armaments is certain to continue since this

is its best means of earning foreign exchange, garnering international influence, and supporting its internal military production requirements. Of its arm sales, the most valuable component has been ballistic missiles, related technology, and missile production tooling.

Missile development

Unfortunately, North Korea has followed China's example and constructed thousands of underground facilities, making it impossible for U.S. intelligence agencies to determine with certainty when specific missile and WMD capabilities will emerge and at what production rate.⁴³ (Note: Iran, Pakistan, Syria, Libya, Iraq, and other states are also putting their key missile production facilities underground, thereby complicating U.S. intelligence collection efforts in their respective countries as well.) North Korea's ballistic missile manufacturing plants are among these underground facilities,⁴⁴ including a missile final-assembly plant employing up to ten thousand workers.⁴⁵

North Korea's exact annual ballistic missile production rate is uncertain and available estimates are based on highly speculative data. Given this limitation, analysts estimate that North Korea has the production capacity to build 100 to 150 SCUD Bs and SCUD Cs per year.⁴⁶ It is known that in 1987-88, North Korea produced 8 to 10 SCUDs per month to fill an Iranian order. According to a RAND analysis, North Korea has exported about 490 SCUD missiles.⁴⁷

In recent years, North Korea's new 1300-kilometer range *Nodong* missile has been the priority production project. Since the *Nodong* is more complex than the SCUD B and C systems, it is estimated that the production rate for the *Nodong*

⁴² "China, Russia Presidents Agree Need for Multipolar World," China Central TV, British Broadcasting Corporation, 9 December 1999.

⁴³ Kim Chong-min, "Monthly Discusses Secret Works in DPRK," *Pukhan* (Seoul), 12 January 1999, translated in FBIS-EAS-99-012; and "ROK Says Over 8,200 Underground Sites in DPRK" *Chungang Ilbo* (Seoul) (Internet version), 8 December 1998, transcribed in FBIS-EAS-98-342. The second article claims that North Korea has constructed over 5 million kilometers of tunnels. It is doubtful that anyone in the West knows for certain the exact number of underground facilities that have been constructed in North Korea, but it is certain that they are very extensive.

⁴⁴ Yi Chae-sung, "Don't Look Down on North Korean Technological Capability," *Seoul News Plus*, 17 September 1998, translated in FBIS; and "ROK Official Comments on DPRK Missile Plants, Bases," *Yonhap* (Seoul), 25 March 1999, transcribed in FBIS.

⁴⁵ Chidanand Rajghatta, "Ghauri Missile Fire Was Lit In North Korea," *Indian Express* (New Delhi), 12 April 1999.

⁴⁶ Report on paper delivered by Professor Kim Chol-hwan, ROK National Defense University. "ROK Military Professor on NK Scud Exports," *Seoul Yonhap* (Seoul), 15 September 1999, transcribed in FBIS. Another North Korean analyst estimated the SCUD production figure at 80 to 120 missiles per year.

⁴⁷ Dr. Jeffrey Isaacson, reported in "ROK Military Professor on NK Scud Exports."

North Korea: Strategic Missiles

Taepodong I

5-10 missiles produced

Range: TD-1 – 1500-2000km (2 stage)
(1st stage *Nodong*, 2nd stage *SCUD-C*)
TD-1 SLV – 6000km+ (3 stage)
(3rd stage solid -fueled)

Payload: 500-1000kg

Deployment: 2000-2002

Taepodong II

1-5 missiles produced

Range: 6000km+ (2 stage)
(new booster w/*Nodong* 2nd stage)

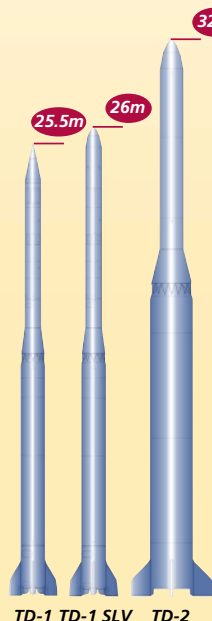
Payload: 500-1000kg

Deployment: 2000-2003?
(may deploy without testing)

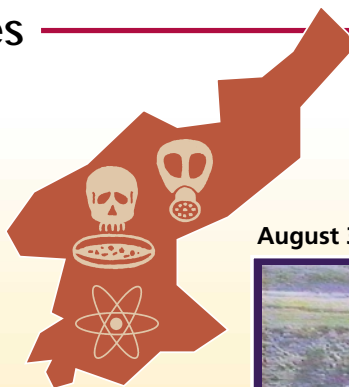
Taepodong (three stage)

ICBM – 10,000km range?

Production Rate: 4-8 per year?



TD-1 TD-1 SLV TD-2



August 31, 1998



Taepodong

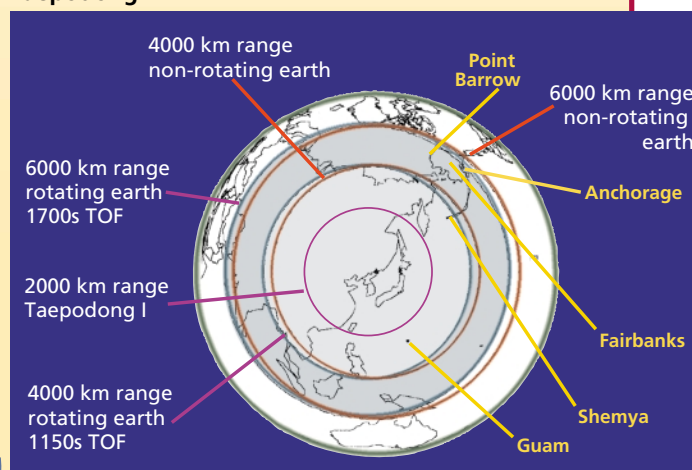


Figure 5

may be approximately 30 missiles per year,⁴⁸ with perhaps as many as 100 to 150 *Nodong* missiles produced to date (including those exported to Pakistan and Iran).⁴⁹ The *Nodong* also serves as the first stage of the three-stage, 6,000-plus-kilometer range *Taepodong I* (TD-1) missile,⁵⁰ which was tested on 31 August 1998. The TD-1 uses a SCUD C for its second stage and, in the one version tested, a small solid-fueled booster rocket for its third stage. Indications are that five to ten TD-1s have been assembled. It is possible that North Korea has also provided this system to Pakistan and Iran.⁵¹

The *Taepodong II* (TD-2) is North Korea's ICBM. Its first stage is believed to be modeled on China's DF-3A missile system, and its second stage is a modified *Nodong*. The system may also include a solid-fueled third stage such as was used on the flight test of the TD-1. In the three-stage configuration, U.S. officials have indicated that the TD-2 would be able to strike the Western half of the United States carrying a significant payload. This characterization indicates that the missile might have a range capability of about 10,000 kilometers. (See figure 5)

⁴⁸ Conversation with Bermudez, October 1999.

⁴⁹ John Donnelly, "ICBM Threat To U.S. By Next Year, General Predicts," *Defense Week*, 1 March 1999, 16.

⁵⁰ Dr. J. David Martin, BMDO, noted in a briefing at the Washington Institute for Near East Studies, March 3, 1999, that the *Taepodong I* demonstrated a range capability of about 6000 kilometers during its satellite-launch attempt, 31 August 1998. Congressman Weldon told reporters that the *Taepodong I* could reach most of the United States with a 200 kilogram payload. See "Ground Zero," *Inside Missile Defense*, 10 February 1999, 1.

⁵¹ John Donnelly, "Iran Has Makings of North Korea's Taepo Dong," *Defense Week*, 24 May 1999, 1.

India: The Agni Program

Agni II

- Solid-fueled IRBM with 2000+ km range
- 1000 kg maneuvering warhead
- First tested April 1999
(3 Agni I's tested previously)
- When fielded India will mount in roving rail cars



Agni III

- Reportedly a system under development with 3500-5000 km range
- Agni III designed to reach Beijing

Sagarika

- Ballistic missile development program for sub-surface launch by submarine
- Reported range 300 km
- Russian assistance being provided for submerged launch technology
- India plans to adapt the Agni for use on its nuclear-powered submarine (2009?)



Figure 6

The United States has worked vigorously to prevent North Korea from testing the TD-2 ICBM, a test that had been scheduled for the summer of 1999.⁵² Reports ascribed to the intelligence community indicate a suspicion that North Korea may field this system without testing. Between one and five of these missile systems are believed to have been produced.⁵³ It is suspected that this system could become operational within the next one to three years. Once developed, this missile could also be exported.

North Korea clearly could not succeed in unifying the Korean peninsula on its own terms if the United States intervened on the side of South Korea. Thus for North Korea, a primary challenge is to develop a deterrent capability that would limit U.S. military action in any future Korean conflict. It seems likely that North Korea's development of an ICBM is aimed at such an objective. Very rough

estimates of North Korea's possible ICBM-production potential indicate that the regime should be able to build at least four to eight ICBMs per year (and perhaps more).

North Korea's nuclear arsenal

North Korea's nuclear capability is uncertain. U.S. officials have claimed repeatedly that North Korea has one or two nuclear weapons. South Korean reports claim that North Korea has up to ten nuclear devices.⁵⁴ The truth is that no one can be certain how large an inventory of nuclear weapons North Korea now possesses. For example, it is known that a significant amount of fissile material is unaccounted for in the former Soviet Union; it is also reported that North Korea has been actively seeking fissile material from Russia. It is difficult to believe that Pyongyang

⁵² Former Secretary of Defense William Perry commented on the test preparations during a presentation at the Wilson Center. See "For the Record," *Washington Post*, 1 December 1999, p. A42.

⁵³ Bill Gertz, "The North Korean Missile Threat," *Air Force Magazine*, January 2000 (Internet version), <http://www.afa.org/magazine/0100missile.html>.

⁵⁴ For example, see "ROK Official: DPRK Suspected to Hold 40 kg of Plutonium," *Chungang Ilbo* (Seoul) (Internet version), 21 November 1999, transcribed in FBIS.

would not have had at least some success in that endeavor.⁵⁵ At the same time, analysts suspect that Pakistan received North Korean missiles in exchange for nuclear assistance.⁵⁶ Thus, any estimate of North Korea's nuclear capability based solely on indigenous production of fissile material should be treated with caution.

North Korea's chemical weapons production

North Korea also has an extensive chemical weapons production infrastructure with an estimated stockpile of about 5,000 tons of chemical agent, running the gamut from mustard gas to VX nerve agent.⁵⁷ In addition, North Korea has a biological weapons program and is believed to have a modest amount of biological agent weaponized. While North Korea might hesitate to employ many biological weapons on the Korean peninsula, out of fear of infecting its own troops, it might not be so wary of off-shore use.

India

Although India is not considered a hostile state, it is making a national effort to develop ballistic missile capabilities. Its solid-fueled *Agni II* will be a mobile missile system with a 2000- 2500-kilometer range. The missile will move around the country by rail, looking like any other standard train (figure 6). Indian officials have also discussed the development of an *Agni III* missile with reported ranges of 3500 to 5000 kilometers.⁵⁸

Most interesting is the fact that India's rumored development of the *Surya* ICBM was publicly confirmed by India's junior defense minister (a political blunder that cost him his job).⁵⁹ Uncon-

firmed news accounts claim that the *Surya* will incorporate the solid-fueled first stage of the polar space launch vehicle as its booster and adapt the solid-fueled *Agni II* missile to serve as the upper stages; other sources claim the design will include a cryogenically fueled stage.⁶⁰ The maximum range of the *Surya* has been reported to be between 8000 and 12,000 kilometers; the missile is expected to begin flight testing soon. Indian reports have made it clear that India is developing MIRVed warheads for its ballistic missiles (figure 7, p. 1.18).

As India becomes an ICBM-equipped nuclear power, analysts question how well it will control its sensitive technologies. In November 1999, Dr. A. P. J. Abdul Kalam, the father of India's indigenous missile program, was appointed scientific advisor to the Indian government and accorded the rank of cabinet minister.⁶¹ In an April 1999 interview, Dr. Kalam made it very clear that if he had his way, India would export its missiles and missile technology.⁶² In addition, although India's official position is to maintain tight control of its missile and nuclear technologies, there have been cases where missile design information is believed to have been leaked, through either espionage or corruption.

Thus, it seems likely that India will join the world's ICBM club during the next decade. It could also become a member of the missile supplier's club, a possibility still to be determined.

Pakistan

Pakistan, a country teetering on the edge of economic collapse, is armed with nuclear weapons and is also making steady progress toward the

⁵⁵ Hong Sang-un, "KSB Speculates on DPRK Train's Radioactive Material," Seoul Television Network, 22 October 1999, translated in FBIS.

⁵⁶ Ibid.

⁵⁷ "DPRK Said To Have Over 5000 Tons of Chemical Weapons," *Yonhap* (Seoul), 4 November 1999, transcribed in FBIS. Note that the author has also seen the figure of 5000 tons in several other references, but no one outside of North Korea can be very certain of the size of the North Korean chemical weapons stockpile.

⁵⁸ "Missile Designed To Keep China At Bay," *South China Morning Post* (Hong Kong), 12 April 1999. Other Indian military officers have used the 5000 kilometer range when discussing the *Agni III*. The 5000-kilometer figure has also been used by Indian insiders in relationship to the ICBM program. However, this claim may be disinformation since a missile is not classified as an ICBM unless it achieves a range of at least 5500 kilometers.

⁵⁹ "Premature Disclosure of ICBM Project: Rawat Stripped of Defence Portfolio," *Ifikhar Gilani* (New Delhi), 23 November 1999.

⁶⁰ Ibid.; and Vivek Raghuvanshi, "India to Renew Focus on Missile Technology," *Defense News*, 25 October, 1999, 24.

⁶¹ "Kalam Appointed Scientific Advisor to Indian Government," *The Indian Express* (New Delhi) (Internet Version), 26 November 1999, transcribed in FBIS.

⁶² Rai Chengappa, "India's Nuclear Scientist on Capability of Agni Missile," *India Today* (Delhi), 26 April 1999, p. 57, transcribed in FBIS.

India: ICBM Potential

PSLV

- Space-Launch Vehicle with powerful, solid-fueled first stage.
- Could be used as 8000 km ICBM

Surya

- Rumored 12,000 km ICBM, in design since 1994.
- Design may use:
 - 1st stage of PSLV (solid fueled)
 - 2nd & 3rd stage Agni II (solid fueled)
- Warhead: likely a thermonuclear device
- MIRVed warhead is being explored
- Indications system could be ready to test in 2001 and deploy in 2003
- The Surya will probably be able to cover the northern half of the U.S.

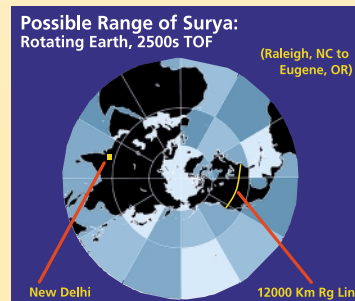
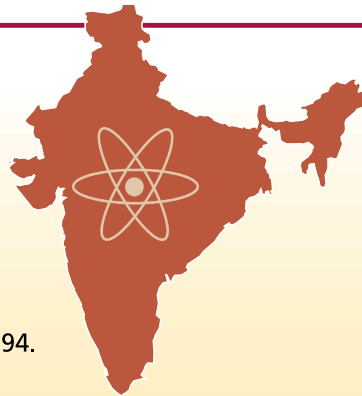


Figure 7

development of ballistic missile delivery systems. Its missile programs are benefiting from both Chinese and North Korean assistance that is generally divided between two different laboratories whose directors have long been legendary rivals.

Khan Laboratories, directed by Dr. A.Q. Khan, the father of Pakistan's nuclear weapon, is working to develop liquid-fueled missile systems based on North Korean designs. In fierce competition with Khan Laboratories is Pakistan's Atomic Energy Commission, headed by Dr. Samar Mubarakmand.⁶³

Dr. Mubarakmand is working with Chinese assistance to develop solid-fueled ballistic missiles. Although Pakistan continually changes the names of its missile programs, it is clear that its liquid-fueled *Ghauri* missile is actually a North Korean *Nodong*. Analysts also speculate that the longer-range, liquid-fueled missiles Pakistan claims to be developing are likely based on North Korean *Taepodong* designs.

In the category of solid-fueled missile systems, Pakistan has test-fired the 11-meter-long *Shaheen* / ballistic missile with a reported range of 750 kilometers. This missile is clearly based on the design of the Chinese M11/M9 family. Pakistan claims that its *Shaheen II*, now in final development, will have a range of over 2000 kilometers. The Indian media claims that the *Shaheen II* will be a two-stage missile. Some reports claim the missile is a Chinese DF-18. Regardless of the specifics of the missile program, as Pakistan continues to develop its missile capabilities and as it proves its multi-stage missile designs, those designs could quickly evolve into long-range strike capabilities, if the country receives the technology it needs to build a survivable reentry vehicle.

Considering Pakistan's desperate economic plight, there is also reason for concern that the country might increase its exports of nuclear and missile technologies to earn foreign exchange. Although somewhat speculative, there is concern in U.S. circles that Pakistan could transfer some of its missile and nuclear technologies to other states in the region, such as to Saudi Arabia as a

"Considering Pakistan's desperate economic plight, there is also reason for concern that the country might increase its exports of nuclear and missile technologies to earn foreign exchange."

– p. 1.18

⁶³ K. Subrahmanyam, "Pakistan's Missiles Not Indigenious," *The Times of India* (Mumbai), 16 April 1999, transcribed in FBIS.

replacement for the Saudis' aging Chinese DF-3A missiles, and to the United Arab Emirates, which is seeking a deterrent against Iranian aggression.⁶⁴ In summary, within the next three years, Pakistan is expected to have multi-stage ballistic missiles capable of targeting Israel and most of India. The unknown question is if it will follow in India's footsteps and try to develop an ICBM and, if it should do so, whether the missile will be exported?

Iran

With one-third of the population of the Middle East, Iran has aspirations of becoming the leading regional state in the Persian Gulf. Based on the lessons learned in the 1980s from the Iran-Iraq war, Iran has since made the development of a complete family of weapons of mass destruction and missile delivery systems a national priority. Iranian observations of U.S. use of precision-strike and missile systems during the 1990s have reinforced this national objective.

Iran's programs are receiving assistance from three primary sources: Russia,⁶⁵ China, and North Korea, including technology for both liquid- and solid-fueled missiles. In addition to personnel from these three countries, Iran has also recruited technical personnel from around the globe to work on its various programs,⁶⁶ thereby establishing the conditions necessary to make the country a major crossroad for information exchange on missile technologies among the personnel of various nationalities working in country.

In addition to an indigenous capability to produce SCUD missiles, Iran has recently acquired the *Shahab III* missile, a renamed North Korean *Nodong* with a range of 1300 kilometers.⁶⁷ Moreover, Iran is known to be working on a 2000-kilometer missile, the *Shahab IV*,⁶⁸ (figure 8) which is

expected to be flight tested within the year. The *Shahab IV* reportedly contains components from the old Soviet SS-4 missile made famous by its role in the Cuban missile crisis of 1962. Iran is claiming that the completed *Shahab IV* missile will be used as an Iranian space-launch vehicle. There



Figure 8

are also reports of a *Shahab V* under development, along with the *Shahab VI*.⁶⁹ It is believed that these latter two missiles are long-range systems, with at least one of them being an ICBM-class missile. Considering Iran's relationship with North Korea, it must be considered that the *Shahab V* or *VI* may be based on the *Taepodong*. There are also reports that an advanced solid-fueled missile is being developed that may incorporate Russian SS-20 technology. Regardless of missile type, it is generally projected that Iran may have the capability of targeting the United States with ballistic missiles sometime during the latter part of the next decade.

Iran also has a nuclear program that is expected to provide it with nuclear weapons during the same timeframe as its ICBM program is likely to be completed (if not before). In addition, Iran has a full range of chemical weapons, as well as an active biological weapons program.⁷⁰

⁶⁴ Simon Henderson, "Pakistan, Proliferation, and the Middle East," *Policy Watch*, no. 415, Washington Institute, 14 October 1999.

⁶⁵ James Risen, "CIA Sees A North Korean Missile Threat," *New York Times*, 3 February 1999, p. A6.

⁶⁶ For a detailed description of Iran's missile-producing facilities, see "Interview With Mikhail Kirillin, Russian Federal Security Service Officer," *Yadernyy Kontrol* (Moscow), 1 March 1998, translated in FBIS.

⁶⁷ For specific details on Iran's missile programs, see Konstantin Eggert, "Meteor for the Ayatollahs: Iran Needs Ballistic Missiles In Order To Become A World Power," *Izvestiya* (Moscow), 21 October 1998, p.5, translated in FBIS; and Konstantin Eggert, "Meteor for the Ayatollahs: Iran Needs Ballistic Missiles In Order To Become A World Power, Part 2," *Izvestiya* (Moscow), 22 October 1998, p. 5, translated in FBIS.

⁶⁸ Ibid.; and Audrey Hudson, "Analyst Fears U.S. Helps Iran Develop Missile Via Moscow," *Washington Times*, 16 July 1999, p. 15.

⁶⁹ For an example, see Kenneth Timmerman, "Iran's Deadly Missile Potential," *Washington Times*, 16 July 1999, p. A15.

⁷⁰ Judith Miller and William J. Broad, "Iranians, Bioweapons In Mind, Lure Needy Ex-Soviet Scientists," *New York Times*, 8 December 1998, p. A1; and "Iran Accused Of Germ Warfare Program," *Washington Times*, circa January 1999.

In summary, Iran has close ties with a number of missile-producing states. In a multipolar world, Iran could be the major power in the Middle East. Its ties with Russia, China, and India put Iran in the company of other states seeking roles as major powers in a multipolar world.

sile program, to include possible Nodong missile components.⁷⁵ Libya is also suspected of having a nuclear weapons development program.⁷⁶ If this is true, it would complement Libya's chemical and biological weapons programs, which are thought to be fairly advanced.

Iraq

Even though Iraq is under UN limitations on missile development, it is known that the country has been actively seeking advanced missile technologies in Russia,⁷¹ and may also have a cooperative missile development program with Libya. The Rumsfeld Commission assessed that Iraq could have an ICBM within five years of lifting UN supervision and a decision by the Iraqi leadership to pursue that course of action.⁷²

Syria

Syria has an active ballistic missile development program that receives assistance from Iran, China, Pakistan, and perhaps Russia.⁷⁷ Syria also maintains an extensive chemical weapons inventory and reportedly is attempting to hire ex-Soviet scientific personnel to work on its biological weapons program.⁷⁸ While there are no indications that Syria is presently seeking ICBMs, the recent change in Syrian leadership could also bring a change in Syria's missile development policy, for either the better or the worse in terms of U.S. nonproliferation policy.

Libya

Although Libya's missile program has been developing slowly, its rate of progress could accelerate with Russian, North Korean, Iranian,⁷³ and Iraqi assistance. Since the UN embargo was lifted, Russian defense firms have been actively seeking contracts in Libya for defense sales. Although no sales of Russian ballistic missile technology to Libya have been reported, ongoing sales of missile technology to other states indicate that the Libyan-Russian connection bears close attention.⁷⁴ In addition, according to recent news reports, North Korea is providing assistance to Libya's mis-

Other states

Although not discussed in much detail, Israel, Saudi Arabia, Taiwan, South Korea, Japan, South Africa, and a number of other states could have been included in the preceding discussion of specific country capabilities. When the number of states involved is considered, it becomes clear that the movement toward missile development is a broad effort involving many states.

⁷¹ Background conversation with a member of the UNSCOM inspection team for Iraq, December 1999. He stated that the team had seen proof that Russian defense firms had signed contracts with Iraqi firms for missile-related technology.

⁷² Barry Blechman, "The Growing Ballistic Missile Threat: How Much, How Soon, and How Dangerous," *Heritage Lectures*, Heritage Foundation, 1 February 1999, p. 3.

⁷³ For example, see "Iran Tested Sea-Launched Ballistic Missile," *Iran Brief* (8 March 1999). The article claims that in a top-secret intelligence report of September 1998, the CIA said "it had detected multiple signs of Iranian involvement in building missile plants and underground launch sites in Libya."

⁷⁴ "Russian Officials To Discuss Arms Sales With Libya," *Interfax* (Moscow), 11 October 1999, transcribed in FBIS; and "Russia To Sustain Military-Technical Ties With Libya," *Interfax* (Moscow), 22 October 1999, transcribed in FBIS.

⁷⁵ For example, see Michael Binyon, "Missiles Find Sours West's Libya Links," *Times* (London) (Internet version), 10 January 2000. A shipment of long-range SCUD missile components was intercepted in London en route from Taiwan to Libya on 24 November 1999. Other shipments of missile parts reportedly had been delivered previously to Tripoli by way of the United Kingdom. The article claims Libya is thought to have acquired *Nodong-I* missiles from North Korea, and that North Korean technicians are working on Libya's missile development program. See also and Nicholas Rufford, "Libyans Smuggle Scuds Through UK," *Sunday Times* (London), 9 January 2000, pp. 1, 2; and "Libya Trying to Buy A North Korean Ballistic Missile," *El Pais* (Madrid), 16 January 2000.

⁷⁶ Bill Shepard, editor of *Jane's Sentinel*, reportedly claimed that Libya might have an operational nuclear weapon by 2005. Rufford, "Libyans Smuggle Scuds Through UK."

⁷⁷ For example, see "Syria Develops Chemical Warheads in Hims," *Yedi'ot Aharonot* (Tel Aviv), 24 December 1999, pp. 4-5, 7, translated in FBIS.

⁷⁸ Miller and Broad.

Sea-based missile developments

Over the next ten years, a few countries are also likely to pursue the capability to launch ballistic missiles from ships.⁷⁹ Although the Russian and Chinese missile submarine development programs were noted earlier, other states could also develop sea-based ballistic missile systems during the next decade. For example, Iran has already tested missile launches from surface ships.⁸⁰ Likewise, India is developing the 250-kilometer *Dhanush* (*Prithvi III*) for use by its naval surface ships.⁸¹ There are hints that a more capable missile may be developed to replace the *Dhanush*.⁸²

With Russian assistance, India is also developing a submarine-launched ballistic missile for deployment on its new nuclear submarine scheduled to be commissioned in the 2009 timeframe. Reportedly, India plans to build five nuclear submarines.⁸³ Although the Indian submarine-launched ballistic missile, the *Sagarika*, has been advertised as having a range of 300 kilometers, other reports indicate that India's ultimate objective is to modify the *Agni II* for submerged submarine launch.⁸⁴ If true, this would indicate that the missile to be deployed on India's nuclear submarine will likely have a range in excess of 2,000 kilometers. Not to be left out, Pakistani sources also claim that their country plans to equip its naval forces with nuclear weapons,⁸⁵ although no mention was made of delivery means.

More speculative are the conjectures that North Korea may have the knowledge to develop sea-

launched ballistic missile systems. North Korea previously purchased some obsolete Soviet ballistic missile submarines for salvage. If the submarines' missile tubes were left intact (which is unknown), this would have allowed North Korea an opportunity to study the launch technology. Although we have seen no indicators that North Korea is developing a sea-launch capability, it is difficult to predict developments in this very secretive and closed society.

Countermeasures against missile defenses

Although the presence of a U.S. national missile defense system may deter some states from building their own ICBM forces, the states that have already begun the effort or that already have an extensive missile capability are expected to develop missile defense penetration aids as U.S. defenses are deployed,⁸⁶ a technology that is not regulated by the Missile Technology Control Regime (MTCR). Considering the accelerating pace of international trade and technology transfer rates, it is likely that international trade in penaid technology will also occur and that Russia and China may be willing to sell that technology.⁸⁷ It is also likely that in the future, biological agents may be packaged in submunitions for ICBM delivery, a development that will increase the need for boost-phase missile-attack capabilities. It should be noted that some biological warheads reportedly were mounted on Soviet SS-18 ICBMs during the 1980s. Thus the technology for such warheads already exists.

⁷⁹ For a good article on this type of technology, see Steven J. Zaloga, "Project Skorpion," *Jane's Intelligence Review*, November 1998. Russia developed a shipboard missile-launch capability in the 1960s as a means of overcoming shortcomings in submarine-launched ballistic missile (SLBM) capabilities.

⁸⁰ "Iran Tested Sea-Launched Ballistic Missile," *Iran Brief*, 8 March 1999, 1. James Woolsey, Rumsfeld Commission member and former director of the CIA, reportedly stated this claim during a congressional forum on 18 February 1999. See also Scott McMahon, "Ship-Based Missiles Surface as Potential Terror Weapon," *Defense News*, 15 March 1999, 27.

⁸¹ "India Plans Naval Version of Prithvi Missile," Reuters Wire Service, 30 November 1998; and Rezaul H. Laskar, "India May Soon Test-Fire Naval Surface Missile," *The Asian Age* (New Delhi), 25 December 1999, p. 3, transcribed in FBIS.

⁸² Laskar.

⁸³ Consortium of Indian Military Websites, 7 January 2000, <http://www.bharut-rakshak.com>.

⁸⁴ Advertising the range of the *Sagarika* as 300 kilometers keeps Russian assistance to India's missile development program more legal in MTCR terms. However, the cost of developing a ballistic missile for submarine launch does not make sense if it will have a range of only 300 kilometers. The reports that the solid-fueled *Agni II* will be adapted for submarine launch are very believable – it makes economic and military sense and it is what the Russians and Chinese are doing with their missile systems. See Manvendra Singh, "Agni II Adds Fire Power to N-Deterrent," *Indian Express* (New Delhi), 12 April 1999, p. 1; and Avinash Shirodkar, "Baptism By Agni," *Daily Excelsior* (Jammu), 21 April 1999.

⁸⁵ "Further on Plans to Equip Navy With Nuclear Capability," *Nation* (Islamabad) (Internet version), 30 May 1999.

⁸⁶ For example, see Major General Vladimir Semenovich Belous (Ret.), "Countermeasures To U.S. ABM System Eyed," *Nezavisimoye Voyennoye Obozreniye* (Moscow), 30 December 1998, translated in FBIS-UMA-98-364. This article is recommended reading.

⁸⁷ U.S. National Intelligence Estimate (NIE), August 1999.

In fact, the September 1999 U.S. National Intelligence Estimate implied that efforts are already ongoing in many countries to develop pen aids. It stated:

Many countries, such as North Korea, Iran, and Iraq probably would rely initially on readily available technologies--including separating RVs, spin-stabilized RVs, RV reorientation, radar absorbing materials (RAM), booster fragmentation, low-power jammers, chaff, and simple (balloon) decoys--to develop penetration aids and countermeasures. These countries could develop countermeasures based on these technologies by the time they flight test their missiles.⁸⁸

Threat summary

Unless something occurs to change the current trend, Russia, China, and North Korea will continue to proliferate missile technology and related hardware to other states, and ICBM capabilities will spread during the next ten years. If North Korea successfully develops a three-stage *Taepodong II* missile, then it is expected that this system will be able to deliver large payloads to continental U.S. locations.⁸⁹ Even now, Alaska and Hawaii could be at risk from the three-stage *Taepodong I* which, if used as a ballistic missile, is believed capable of delivering a significant payload to those two states. Learning from the surprise launch of the

three-stage *Taepodong I* missile on 31 August 1998, many defense specialists now would not be surprised to see North Korea test an ICBM capable system within the next year or two,⁹⁰ or perhaps even begin the deployment of such a system without testing during that same timeframe.

It is also assumed that Iran, India, and perhaps Iraq and Pakistan could develop an ICBM within five years of deciding to do so; Syria and perhaps Libya might also be able to develop ICBMs within 10 years of such a decision.⁹¹ Furthermore, the possibility remains that the international transfer of complete missile systems or of major critical assemblies could provide some states with long-range missiles earlier than indicated in the foregoing discussion (such as a North Korean transfer of TD-2 missiles to other states); a few states might also develop a sea-based launch capability. Thus, it is apparent that the current trend will result in more states of questionable stability being able to hold the United States at risk of ballistic missile attack in the future than is the case today.

Clearly, the ability of more countries to threaten the United States with ballistic missiles will make it more difficult for the world's remaining superpower to defend its national interests, including maintaining global stability, protecting its access to oil, deterring terrorism, and providing security for its allies. Unfortunately, this situation promises to accelerate the movement by other states to acquire long-range ballistic missiles and weapons of mass destruction as they move to provide for their own security.⁹²

⁸⁸ U.S. National Intelligence Estimate, 9 September 1999. Note that when U.S. Representative Christopher Cox was trying to have the Cox Committee's report on China released to the public in early 1999, he complained in a televised interview that the intelligence community was trying to persuade the committee to qualify the findings to be released in unclassified form by changing the committee's wording to more tentative terms (could, might, may be, probably, etc.). Based on that indication of how the intelligence community words its public statements of known ongoing activities, it seems fairly certain that North Korea and other countries are already developing warhead packages that are more advanced than those normally seen on first-generation missile systems. The NIE's claim that Russia and China "are probably willing to sell the requisite technologies", noted *ibid*, may indicate that the transfer of countermeasure technologies is already occurring.

⁸⁹ James Risen, "CIA Sees a North Korean Missile Threat: Director Says Rockets Under Development May Be Able to Hit U.S.," *New York Times*, 3 February 1999, p. A6; and George Tenet and LTG Patrick Hughes, testimony before the Senate Armed Services Committee, *Congressional Record*, 2 February 1999.

⁹⁰ Since China reportedly is helping North Korea, it is possible that North Korea's technical potential to develop an ICBM soon could be more advanced than previously assessed. See Bill Gertz, "China Assists North Korea In Space Launches," *Washington Times*, 23 February 1999, pp. A1, A10. Lt. Gen. Lyles, then director, BMDO, stated that there is "little doubt" a new ballistic-missile threat to the U.S. will emerge by 2000. See John Donnelly, "ICBM Threat To U.S. By Next Year, General Predicts," *Defense Week*, 1 March 1999, 1.

⁹¹ The time estimates primarily are based on information released by the Commission To Assess the Ballistic Missile Threat To the United States, 15 July 1998; subsequent to the commission's report, commission members determined that recent developments indicate that Iraq should be added to the list of countries that could develop an ICBM within five years of a decision to do so. See Barry Blechman, "The Growing Ballistic Missile Threat: How Much, How Soon, and How Dangerous," *Heritage Lectures*, Heritage Foundation, 1 February 1999, p. 3.

⁹² Blechman, "The Growing Ballistic Missile Threat: How Much, How Soon, and How Dangerous," *Heritage Lectures*, Heritage Foundation, 1 February 1999, p.3.



U.S. Policy: The Arms Control and NMD Dichotomy

Throughout the 1990s, the United States faced a serious challenge dealing with the wreckage left from the demise and collapse of the Soviet Union. Early in the decade, no one was certain if the “Evil Empire” was gone for good, or if the calm was but the eye of the storm. Consequently, there was a rush to codify in arms control agreements major reductions in the residual military arsenal of the former superpower. There was also an overriding need to ensure that the vast nuclear, chemical, and biological arsenals of the former empire were kept under firm control. The Conventional Armed Forces in Europe (CFE) Treaty (1990), the passage of the Nunn-Lugar Act (1991), the signing (1991) and ratification of the Strategic Arms Reduction Talks (START) I Treaty (1992), and the signing of the START II treaty (1992), were all part of the attempts made by the United States to deal with the situation. The emphasis was on arms control, not on national defense.

The administration, arms control, and NMD

When President Clinton came to office in 1993, the administration focused on helping Russia improve security and accountability for its stockpile of fissile materials and nuclear weapons, while concurrently working to implement the provisions of the START I treaty and gain START II treaty ratification. The administration’s thinking was that since the greatest threat to U.S. security was the huge stockpiles of residual Cold War nuclear weapons, the focus of U.S. nuclear policy should be to reduce the nuclear inventories of both Russia and

the United States. Only recently has the administration begun to recognize the need to consider national missile defense more closely.

The need for NMD, however, conflicts with the desire of the administration to achieve further bilateral reductions in nuclear inventories. Deployment of even a limited national defense system would violate the terms of the Anti-Ballistic Missile (ABM) Treaty, and Russia has made it clear that its participation in the START I and START II treaties depend upon continued U.S. adherence to the ABM treaty. (The full text of the 1972 ABM

treaty, its 1974 Protocol, and Agreed Statements specifying bilateral understandings of the treaty's provisions are reproduced at Appendix A.)

The dilemma

The Clinton administration publicly stated on many occasions that it was strongly committed to the preservation of the ABM treaty, which it considered a "cornerstone of security"¹ and indispensable to stability. The administration long opposed NMD, an antipathy that was reinforced by the fact that some senior policy makers questioned the need to confront the NMD issue at all. They pointed to the historical success of offensive deterrence under the Mutual Assured Destruction (MAD) doctrine, which is generally credited with having deterred the use of nuclear weapons since the end of World War II. Those individuals wondered, for example, why the leaders of a country such as North Korea would fire a ballistic missile at the United States knowing that such an act would result in the destruction of their country. This underlying skepticism of the need for a national missile defense system helped strengthen the administration's resolve to protect the arms control legacy of the Cold War era.

For better or worse, many of the Cold War's arms control agreements have now begun to crumble.² The provisions of the CFE treaty have been violated or unilaterally suspended (for example, Russia announced that it would not adhere to the treaty's flank limits during its 1999 Chechnya operations), and the proliferation of weapons of mass destruction and long-range ballistic missile delivery systems is occurring

regardless of the existence of arms control measures and regimes to prevent it.

Such international proliferation developments and trends have been pushing the administration to address NMD more directly. As was detailed earlier, ballistic missile threats are growing. Analysts now widely agree that a number of new states will develop the capability to threaten the United States with a ballistic missile attack sooner than projected. In a reversal of its previously held judgment, the U.S. intelligence community reported in 1999 that by 2015 any country in the world will be able to develop or purchase outright an ICBM if the leadership of that country should decide that it wants that capability.³

For better or worse, many of the Cold War's arms control agreements have now begun to crumble.

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As a result of this sea change in its threat estimate, the administration now faces a major dilemma. If the United States deploys a limited national missile defense as now seems likely, it may have to withdraw from the ABM treaty to do so. Such an action could trigger an international reaction that would accelerate deterioration of the current arms control regimes that the administration seeks to preserve.

Adding fuel to these concerns is Russia's hard-line response to U.S. proposals to modify the ABM treaty. Russian policy makers have issued a series of angry statements claiming that Moscow will withdraw from the START treaties and ramp up production of new strategic weapon systems if the United States fails to abide by its current ABM treaty commitments. If Russia made good on these threats, some fear that the United States would miss out on the opportunity to lower the level of strategic strike capabilities currently held by both countries. The administration does not wish its legacy to include having "lost" START.

¹ For example, see U.S. Arms Control and Disarmament Agency (ACDA), "The Anti-Ballistic Missile Treaty," *Fact Sheet*, 20 May 1996. As recently as 3 February 1999, this position was reaffirmed in a letter by Samuel Berger, national security affairs assistant to the President, to Senator Carl Levin. See "Berger Letter on NMD Legislation," *Inside the Army*, 8 February 1999, 10.

² For a thought-provoking overview of the nuclear nonproliferation problem, see Michael Barletta and Amy Sands, eds., "Nonproliferation Regimes At Risk," *CNS Occasional Papers*, no. 3, Center for Nonproliferation Studies, Monterey Institute of International Studies, November 1999, <http://www.cns.miis.edu/pubs/opapers/op3/index.htm>.

³ Based on a Jane's report on the new National Intelligence Estimate, see Bryan Bender, "Any Country Can Have An ICBM By 2015, Says CIA," *Jane's Defence Weekly*, 5 May 1999.

However, the administration also does not want to be held responsible for leaving the American people easy prey to rogue-state threats such as could soon emerge from North Korea.

Further complicating the issue is the fact that many in the administration are voicing concern about the potential reaction of China if the United States fields an NMD system. They point to China's small strategic nuclear force and postulate that the deployment of an NMD system will force China to increase its strategic strike capabilities to the level required to overwhelm U.S. missile defenses.⁴ Others hypothesize that China might react by proliferating missiles and WMD technology to other states in order to dilute the effectiveness of U.S. missile defense efforts. Since the U.S. engagement policy is designed to lead China toward a peaceful transition to a democratic system, the administration clearly would like to avoid creating a situation that pushes China toward proliferation activities certain to raise Sino-American tensions.

As a result, the administration is caught between two difficult positions. It wishes to preserve the arms control legacy it inherited (and is afraid of destroying by withdrawing from the ABM Treaty). At the same time it now wants to be able to take credit for acting in a timely fashion to protect the American people from potential missile attack by rogue states.⁵

Congress, arms control, and NMD

Congressional concern over the lack of a U.S. missile defense capability has been increasing in recent years and has provided most of the momentum for deploying an NMD system. In 1999, this concern resulted in the passage of the National Missile Defense Act (by a veto-proof majority and over the objections of the administration), which stated:

Section 2. *It is the policy of the United States to deploy as soon as technologically possible an effective National Missile Defense system capable of defending the territory of the United States against limited ballistic missile attack (whether accidental, unauthorized, or deliberate) with funding subject to the annual authorization of appropriations and annual appropriation funds for National Missile Defense.*

Section 3. *It is the policy of the United States to seek continued negotiated reductions in Russian nuclear forces.⁶*

Many members of Congress have become troubled by the question of whether or not the nuclear deterrence doctrine, developed under the conditions of a Cold War bipolar world, will work in future crisis situations involving states that appear to operate on different nuclear warfighting assumptions than those used by the United States and the Soviet Union. For example, during the Cold War the United States (and, we believed, the Soviet Union) viewed nuclear armaments as weapons of last resort, or as a basis for mutual deterrence. In contrast, many fear that rogue states or certain non-state actors may envisage nuclear capabilities as weapons of first resort, to be threatened or employed to prevent the United States from intervening militarily in regions of major importance. According to this strategic logic, deployment of a U.S. national missile defense system is clearly warranted.

At the same time, many members of Congress still hope that the arms control regimes initiated during the Cold War era can be used as vehicles for further reducing the levels of nuclear arms held by both the United States and Russia. Thus, the internal con-

...many in the administration are voicing concern about the potential reaction of China if the United States fields an NMD system.

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⁴ For example, see "China May Retaliate To U.S. Interceptor Missiles in Alaska," *ITAR-TASS*, 22 September 1999. The report cites statements made by Spurgeon Keeny, president of the Arms Control Association, and James Mulvenon, senior staff member, RAND Corporation.

⁵ At a November 1999 conference, the U.S. under secretary of defense for policy, made it clear that the administration wanted to preserve the ABM Treaty and protect the American people from rogue-state missile threats. Walter Slocombe, "National Missile Defense," Center for Security and International Studies (CSIS) *Statesmen's Forum*, 5 November 1999.

⁶ National Missile Defense Act of 1999, 106th Cong., 1st sess., H.R. 4.

tradition in the National Missile Defense Act of 1999 between the NMD policy and the arms control policy clearly points to the continuing tension between NMD requirements and arms control desires, a conflict that has marked the NMD debate since its inception. (For a short historical overview of U.S.-Soviet/Russian ballistic missile defense activities, see Appendix B.)

Further exacerbating congressional concern is the fragility of Russia's economic and political system. This has raised serious concerns over the reliability of Russia's nuclear command-and-control system and the possible consequences of a breakdown in central authority in Russia. The two edges of this situation are a desire to press for further reductions in nuclear forces and the security concern that if a Russian missile were to be launched accidentally at the United States today, nothing could be done to stop it.

To a lesser degree, China's evolving strategic strike capabilities under conditions of potential domestic instability raise similar concerns, especially as it prepares to field mobile land-based ICBMs and long-range sea-based missiles on a new class of nuclear submarines. There appears to be less concern with China as a result of reports indicating that Beijing does not keep warheads mounted on its missiles during peacetime operations. Nevertheless, this could change as China begins to deploy mobile and sea-based ICBMs, some of which will undoubtedly be kept in higher states of launch readiness.

To add more complexity to the situation, the pro-NMD deployment factions have had difficulty agreeing among themselves on a course of action for responding to the growing missile threat. At least three factions support divergent streams of thought as to what type of system should be fielded:

- One group advocates the deployment of national missile defenses on U.S. Navy *Aegis*-equipped missile cruisers and destroyers.

This faction argues that with the current and planned investment for *Aegis*-capable cruisers and destroyers, it would be cost-effective to equip these vessels with missiles capable of intercepting ICBMs, thus defending all fifty states with sea-based missiles.⁷

- A second, smaller group wants to limit the amount of resources being absorbed by terrestrial-based missile defense efforts, preferring to use available funds to move rapidly toward space-based defensive systems, a system that could provide global coverage and would negate ongoing efforts to use penetration aids to overcome missile defenses.
- The third group advocates a limited ground-based defense, but has some internal disagreements as to where this defense should be located and whether or not it should comply with the terms of the ABM treaty.⁸

These divergent views add another layer of difficulty to the task of building a political consensus on a long-term national missile defense program. Obviously, if the policy community is to come to an agreement, common ground must be found for discussing the complex issues associated with arms control and the potential for fielding an effective national missile defense system.

Arms control: the hinge issue

As outlined earlier, the primary concern that many voice about fielding a national missile defense system is its potential for weakening arms control. According to this perspective, the real issue is not the ABM treaty itself, but its potential for disrupting the START treaties and possibly the Nuclear Nonproliferation Treaty (NPT) and the Missile Technology Control Regime (MTCR) as well. During the mid-1980s, the Soviet Union threatened to walk away from START if the United

⁷ For example, see the Heritage Foundation's Commission on Missile Defense, *Defending America: A Plan to Meet the Urgent Missile Threat* (Washington: Heritage Foundation, March 1999).

⁸ For example, see K. Scott McMahon, *Pursuit of the Shield: The U.S. Quest for Limited Ballistic Missile Defense*, with Foreword by Sen. John Warner (Lanham, MD: University Press of America, 1997). McMahon argues that the United States should establish a multisite, ground-based NMD system while maintaining the option to deploy space-based weapons if warranted by future threat developments.

States fielded the Strategic Defense Initiative (SDI). More recently, as already noted, Russia has used the threat of withdrawal from START to keep the United States from modifying the ABM Treaty and deploying even a limited NMD system that could defend against a rogue-state threat, but not be sufficient to destroy all missiles that Russia is capable of launching.⁹

The role of the START treaties

Although the 1992 START I treaty is well on its way toward full implementation by its 2001 target date, the START II treaty has yet to enter into force. The key elements of START II specify that each party reduce the level of deployed warheads as follows by 1 January 2003:

- Each party will reduce the level of fielded strategic warheads to an overall limit of between 3000 and 3500 warheads deployed on ICBMs, SLBMs, and heavy bombers. Heavy bombers will not exceed 100 aircraft at any one time.
 - No more than 1750 warheads will be deployed on SLBMs.
 - No warheads will be deployed on heavy ICBMs.
 - No more than one reentry vehicle will be deployed on ICBMs (that is, all launchers, whether deployed or not, are included in the restriction on MIRVed ICBMs; downloading of buses for carrying multiple warheads is permitted without replacing the bus platform--see figure 1).

Russia and the United States completed negotiations for the START II treaty during the post-Cold War honeymoon period of the early 1990s, when relations between the two countries were at their peak. Even so, right from the beginning START II generated a storm of criticism and opposition in Russia. Consequently, Russian ratification of the

treaty was frequently delayed by internal political turmoil, reluctance by the Yeltsin administration to push for ratification, NATO expansion tensions, election cycles, and tactical maneuvering in the *Duma* to avoid ratification action. By 1997, it was clear that the START II Treaty was in jeopardy and would not be ratified unless some of the underlying Russian concerns could be addressed.¹⁰ At the Helsinki Summit of March 1997, Presidents Clinton and Yeltsin reached a conceptual agreement on how to deal with some of the strategic security concerns that were disrupting the START II ratification process (the Helsinki agreements).

In September 1997, the two countries formalized one portion of the March 1997 Helsinki agreements by signing the START II Extension Protocol which postpones by five years the treaty implementation deadline from 1 January 2003 until 31 December 2007. Among other considerations, "this delay permits Russia, by prolonging the life of some of its MIRVed ICBMs, to synchronize their natural rate of decommissioning with treaty requirements"¹¹ (that is, Russia can eliminate the missiles as they become obsolete). The extension protocol also aligns the implementation dates for the anticipated START III agreement with the new START II implementation schedule. This is intended to allow Russian dissatisfaction with certain aspects of START II to be redressed in the new negotiations. The most serious problem Russia has with the START II treaty appears to be

MX RVs Loaded On Bus



START II requires all but one RV be removed from existing buses on ICBM systems.

Figure 1

⁹ See, for example, the Russian defense minister's comments in Pavel Koryashkin, "Sergeyev: U.S. Quitting ABM Treaty Will Spiral Arms Race," *ITAR-TASS*, 24 December 1999, transcribed in FBIS.

¹⁰ Alexander A. Pikayev, "The Rise and Fall of START II: The Russian View," *Carnegie Working Papers*, Carnegie Endowment, September 1999, chap. 3, p. 5 (Internet: <http://www.ceip.org/programs.npp/pikayev.htm>). This study is recommended reading. It pulls together many of the articles and research the author has seen in bits and pieces elsewhere. Much of the history and background herein on START II in Russia was extracted from this excellent study.

¹¹ *Ibid.*, chap. 2, p. 6.

the requirement to reduce the payload of all land-based MIRVed ICBMs to just a single warhead.

Russia's START II dilemma

In refusing to ratify START II, the Russian *Duma* had claimed that it was not in Russia's interest to give up the right to MIRV its land-based missile force. Under START II, each country can maintain MIRVed warheads deployed on submarines, but all land-based missiles can only carry single warheads. In addition, the warheads on all 360 Ukrainian-built, heavy SS-18 missiles would have to be removed. When the decline in the Russian submarine force is factored into the equation, it appears that for Russia to field its START II quota of unitary warhead ICBMs and MIRVed SLBM missiles, the country would have to build about 1500 new missiles to maintain the START II authorized strike force.¹²

As discussed earlier, Russia is currently having difficulty producing approximately 10 strategic missile systems per year, let alone finding the resources required to develop a more robust missile production capability. Consequently, *Duma* members had been reluctant to exacerbate the situation by voting to ratify START II and increase the overall requirement for ICBM boosters and launch crews. By comparison, to maintain the START I sub-limit of 4900 warheads on deployed strategic missiles would require that Moscow only produce 490 new MIRVed missiles.¹³ Russian legislators asked why they should ratify START II and incur a threefold increase in strategic missile procurement requirements. Since neither pro-

curement requirement is within Russia's reach, the *Duma* had been inclined to opt for the smaller requirement.

To minimize their problem, Russian officials indicate in comments and published articles that they want to prolong the deployment of the heavy SS-18 ICBMs until 2008, nearer to the end of that missile's life expectancy. They also want to deploy the new *Topol M* SS-27 (figure 2) as a MIRV with three or four reentry vehicles (figure 3), a change that would reduce Russia's procurement requirements for missile systems. Russian policy makers are also hoping for

an economic recovery that would support a larger missile procurement program in the future. Without a significant improvement in the Russian economy, some Russian officials fear that the country's strategic force could be numbered only in the hundreds of warheads within the next two decades.¹⁴

Faced with the pending decline in Russian nuclear capabilities in

the future, President Putin made Russian ratification of the START II Treaty a priority issue for *Duma* consideration. It is clear from comments he subsequently made that he views START II as a tool that can be used to fight against U.S. deployment of an NMD system. Consequently, on April 14, 2000, the *Duma* approved the START II bill of ratification, a bill which includes conditions that many U.S. Senators will undoubtedly find distressing. Although the exact wording of the conditions attached to Russia's START II ratification were not yet public as of the time this study was finalized, it is clear that Russia is making ratification conditional on continued U.S.

SS-27 Launch Vehicle



Russia's economic woes raise questions on how many new missile systems can be procured. START II will require a launcher/missile per warhead (no MIRVs).

Figure 2

¹² Ibid., chap. 1, p. 4.

¹³ Ibid.

¹⁴ Ibid., chap. 1, p. 2.

adherence to the ABM treaty and U.S. ratification of the 1997 ABM multilateralization and demarcation agreements reached in New York.¹⁵

However, the 1997 agreements face significant opposition in the U.S. Senate. The demarcation agreements would limit the technical capabilities of future U.S. tactical missile defense systems (that is, cause them to be “dumbed down”). The multilateralization amendment would increase the number of recognized state parties adhering to the ABM treaty, thus making it more difficult to negotiate future changes to the regime. Since none of the new treaty signatories has ICBMs, many senators see this amendment as an administration ploy to lock the United States more tightly into an outdated treaty regime.

Since the Russian ratification of START II contains the conditional provisions outlined above, the responsibility for bringing START II into force now falls on the United States. If the Senate rejects the Russian conditions attached to START II, Washington will become the party responsible for the demise of the treaty designed to reduce the size of the U.S.-Russian strategic arsenals.¹⁶ The shifting of responsibility to Washington for a potential failure to implement the START II Treaty is clearly part of Russia’s diplomatic offensive to stop or limit U.S. development of a effective national missile defense system.

Dealing with the ABM treaty

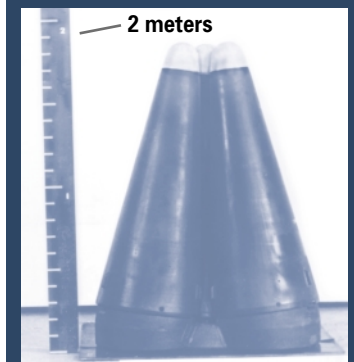
The ABM treaty has been a vexing problem primarily because Russia has linked it to the START process, and because the administration is determined to preserve the treaty. The deployment of a limited national missile defense system, as specified by the National Missile Defense Act of 1999, will require either withdrawal from or modification of current ABM treaty provisions. Without modification or formal treaty termination, a sea-based, space-based, or (arguably) land-based system designed to defend all fifty states is not legally

possible. While the more frequently asked question is what the United States should do about the ABM treaty,” the more pressing question is what fundamental strategy the United States wants to follow regarding its future national security and the role of missile defenses. It is the underlying strategy that should shape the country’s approach to arms control issues.

In recent years, at least four potential U.S. courses of action have been suggested for dealing with the ABM treaty conundrum. These are:

- Officially terminate U.S. adherence to the ABM treaty. Two different approaches have been proposed:
 1. The first would officially declare the ABM treaty to be null and void as of the date that the Soviet Union (the other party to the treaty) ceased to exist. A strong legal case has been made that under international law Russia cannot be designated as a successor state to treaties signed by the former Soviet Union. Hence the treaty is no longer valid.
 2. The second approach would have the United States withdraw from the ABM treaty six months after providing notification of intent to do so, as provided by Article 15.
- Negotiate the minimum treaty changes required to deploy a limited land-based defense (the Clinton administration is taking this approach).
- Negotiate a START III treaty with Russia which subsumes the ABM Treaty issues within a new strategic arms control agreement with Russia (it is also an attractive option to the Clinton administration).
- Unilaterally reinterpret portions of the ABM Treaty to allow deployment of a

SS-20 3-RV Warhead



Russia wants to equip the SS-27 with a similar capability.

Figure 3

¹⁵ Alexander A. Pikayev, “The Rise and Fall of START II: The Russian View,” *Carnegie Working Papers*, Carnegie Endowment Internet, September 1999, chap. 3, p. 5; Ilya Bulavinov, “Warhead Calling Kettle Black: START II May Not Come Into Force,” *Kommersant* (Moscow), April 18, 2000, p. 10, translated in FBIS; and Natalia Panshina, “Putin--START II Ratification Allows Russia To Take Offensive Position in Talks on International Security,” *ITAR-TASS* (Moscow), April 15, 2000, transcribed in FBIS.

¹⁶ *Ibid.*, chap. 3, p. 6; and Ilya Bulvinov “Duma Likely To Ratify START II With Caveats,” *Kommersant* (Moscow), 22 March 2000, p. 3, translated in FBIS.

land-based NMD system at Grand Forks and use the *Aegis* Navy Theater Wide (NTW) (Block II) missile defense system and land-based Theater High-Altitude Air Defense (THAAD) interceptors to defend Alaska and Hawaii against a rogue-state ICBM attack.

These options are elaborated below.

Option 1: Officially terminate the ABM treaty

Two proposals have been put forward for terminating U.S. participation in the ABM treaty regime. The first is based on the fact that the ABM treaty was signed with the Soviet Union, a state that no longer exists. According to international law and a long history of legal precedents, the United States is no longer bound by the ABM treaty. Three very detailed and convincing studies have been conducted that prove this point extremely well.¹⁷ However, U.S. government experts on international law claim that since the Bush and Clinton administrations have assured the Russians on numerous occasions that the ABM treaty is still in force, the United States has established by “state’s practice” in both administrations that Russia is the legal successor to the Treaty. These experts also claim that by international law, state’s practice is more compelling than is legal precedent for determining the status of the ABM treaty.¹⁸

In examining this issue, it becomes clear that the real problem with the validity of the ABM treaty is that two successive U.S. presidents have publicly committed the United States to continuing to observe that agreement and have named Russia as the successor state. Although this U.S. commitment may have had little basis in international law, it does create a tricky political challenge internationally if the United States should now decide (one decade after the fact) to reverse its public position on the validity of the ABM

treaty. Thus, a decision to abrogate the ABM treaty is, in fact, a political issue as well as a legal one. As the three comprehensive studies cited earlier convincingly show, the United States has legal grounds for abrogating immediately its ABM treaty obligations, but the international political costs could be substantial.

The second termination proposal is for the United States to exercise the withdrawal provision permitted under Article 15 of the ABM treaty. Article 15 allows either party to withdraw with six months’ prior notification “if it decides that extraordinary events related to the subject matter of this treaty have jeopardized its supreme interests.” (See ABM treaty text, appendix A.) With the proliferation of ballistic missile technology in countries such as North Korea, Iran, and Iraq, the case can be made that the United States is justified in withdrawing from this bilateral treaty obligation in the face of the emergence of ballistic missile threats from countries that were never parties to the ABM treaty. Those who propose this course of action claim that a withdrawal under the provisions of the treaty would be better for future U.S. arms control efforts than would unilateral reinterpretation of ABM treaty provisions that might set a precedent for other states unilaterally to reinterpret those treaties that bind them to arms control regimes that are clearly in the U.S. interest.

Those who identify most strongly with the arms control community reject U.S. withdrawal from the ABM treaty. This was the first treaty made with the Soviet Union that established strategic weapons limitations during the Cold War. Thus, it is seen as the cornerstone of the bilateral arms control efforts that marked U.S.-Soviet strategic relations for nearly two decades. They fear that withdrawal from the ABM treaty will lead to the collapse of the entire arms control edifice built between the world’s two greatest nuclear powers.

¹⁷ There are three documents which make this case: George Miron and Douglas J. Feith, *Memorandum of Law: Did the ABM Treaty of 1972 Remain in Force After the USSR Ceased To Exist in December 1991 and Did It Become A Treaty Between the United States and the Russian Federation?* (Washington, DC: law firm of Feith & Zell, P.C., 22 January 1999); Robert F. Turner, *The ABM Treaty and the Senate: Issues of International and Constitutional Law* (Charlottesville, VA: Center for National Security Law, University of Virginia School of Law, 1999); and David B. Rivkin, Jr., Lee A. Casey, and Darin Bartram, *The Collapse of the Soviet Union and the End of the 1972 Anti-Ballistic Missile Treaty: A Memorandum of Law* (Washington, DC: Heritage Foundation, 1998).

¹⁸ The opposing arguments were outlined by attorneys with the U.S. Department of State, in March 1999.

Other security strategists, however, point out that the ABM treaty was negotiated to deal with a specific set of circumstances that are no longer major factors in international affairs. During the Cold War, the Soviet Union maintained overwhelming conventional force levels poised against Western Europe. As missile accuracy improved and the Soviet Union made significant progress in preparing its civil defenses (especially for the protection of the nomenklatura), fears grew in the United States that the Soviet Union could use its MIRVed missile systems to preempt much of the U.S. land-based strategic force, leaving the United States with an inadequate retaliatory capability.

In the preemptive first-strike scenario envisioned in the early 1970s where a Soviet first strike would so enfeeble the United States that it could not retaliate effectively, the Soviet Union, with an intact residual nuclear force and an effective civil defense system, would have a second-strike means of destroying remaining U.S. cities. It was feared that the United States, in contemplating such an exchange, would be self-deterred, while the Soviet Union could engage in nuclear blackmail. Thus, the ABM treaty was intended in part to reduce the Soviet incentive to build a large and highly accurate counterforce nuclear capability. At the time that the ABM treaty was negotiated, it was considered a small price to give up the possibility of establishing national missile defenses in return for an assurance that the United States would be able to retaliate against a Soviet nuclear attack and thus preserve the essential deterrence basis for mutual assured destruction.¹⁹

These strategists further maintain that with the withdrawal of Soviet forces from Eastern Europe and the subsequent demise of the Soviet Union, the rationale for a preemptive nuclear attack against the United States by Russia has evaporated. Even if Russia could destroy most of the U.S. land-based nuclear forces, it is not in a position to exploit that success by seizing Western Europe. It also is not capable of destroying the U.S. subma-

rine-based nuclear strike force. According to this strategic logic the Clinton administration's focus on balancing numbers of U.S.-Russian strategic warheads is a remnant Cold War policy that is now proving to be an unnecessary waste of U.S. resources in the new era. The new era demands new priorities and policies, not a continuation of Cold War arms control efforts that were originally designed to contain Soviet power.

Option 2: Negotiate the minimum treaty changes required

This proposal suggests that the United States need only renegotiate the portions of the ABM treaty that prevent the deployment of a limited one- or two-site NMD system, with subsequent protocols to be negotiated only when needed to modify the ABM regime to conform with an altered security environment.²⁰ The current arms control agenda would not be disrupted and future ABM issues would be left to the next administration to handle.

The advantage of this solution is that it could be negotiated fairly quickly because few ABM treaty changes would be required. The Clinton administration has followed this course of action. Its goal is to negotiate sufficient modifications to allow the United States to deploy 100 missile defense interceptors in Alaska, and then leave to the next administration any further treaty changes that might eventually be required.²¹ However, considering ongoing Russian political maneuvering, the upcoming American elections, and Russia's persistent opposition to any ABM treaty modification, even this modest proposal is likely to prove difficult to execute as key decision makers are distracted by domestic politics.

The major disadvantage of this course of action is that it is likely to require renegotiation of the ABM treaty every few years, a condition that is

...a decision to abrogate the ABM treaty is, in fact, a political issue as well as a legal one.

– p. 2.8

¹⁹ The genesis of the ABM treaty was described by Ambassador James Woolsey at a conference entitled *Assessing National Missile Defense: A Roundtable Review*, organized by IFPA, Reserve Officers Association Building, Washington, D.C., 5 May 1999.

²⁰ For example, Steven Andreasen described this idea at IFPA's conference *Assessing National Missile Defense: A Roundtable Review*.

²¹ Walter Slocombe, "National Missile Defense."

likely to spawn a perpetual malignancy in U.S.-Russian relations. Each time the political wound created by treaty negotiations begins to heal, the U.S. will be forced once again to negotiate treaty revisions. In addition, the ABM treaty debate will continue to preoccupy the U.S. national security policy community. In short, this approach will likely result in the ABM treaty's becoming a source of discord for many years to come in the United States' relationship with Russia.

This course of action also has another disadvantage. If the Clinton administration negotiates ABM treaty changes and presents them to the Senate for ratification consent this year, the Senate would be in a quandary. If it votes for ratification, it could make it very difficult for the next administration to withdraw from the treaty, if it so chose, in order to pursue a more ambitious deployment program. This quandary could prompt the Senate to delay consideration of the ABM treaty amendments until after the November 2000 election. (Such a delay could create an election issue if the administration charged the Republican-controlled, pro-missile-defense Congress with slowing the nation's missile defense program.)

Option 3: Negotiate with Russia a START III Treaty that subsumes the ABM treaty issues

The U.S. START III negotiation plan is aimed at lowering strategic nuclear warhead limits for the United States and Russia along with some other provisions dealing with warhead disposition and limits on tactical nuclear systems.²² Some strategists have postulated that if the new START III Treaty contained provisions allowing tradeoffs between offensive and defensive missile systems, the ABM treaty issue could be absorbed by the START III agreement, allowing the more contentious ABM treaty amendment issue to be rolled more gracefully into a new capstone strategic arms agreement. Within this framework, the ABM Treaty restrictions on sensors would disappear and the only control would be on numbers of missiles and warheads, with flexibility to mix between offensive missiles and warheads and defensive systems.

Although this approach appears to be a straightforward negotiating task, it has some potential problems. For example, to destroy one offensive missile usually requires several defensive interceptors. Therefore the task of negotiating a trade-off ratio between how many defensive interceptors a country can field for each offensive missile withdrawn from service would be a major sticking point. Yet, if a country could only field one interceptor for every offensive missile given up, it obviously would not be in that country's interest to field a very robust defense. In addition, those advocates of sea-based and space-based missile defenses may well fight the ratification of such an agreement since it would probably close the door on further consideration of such a capability.

Option 4: Unilaterally reinterpret portions of the ABM treaty

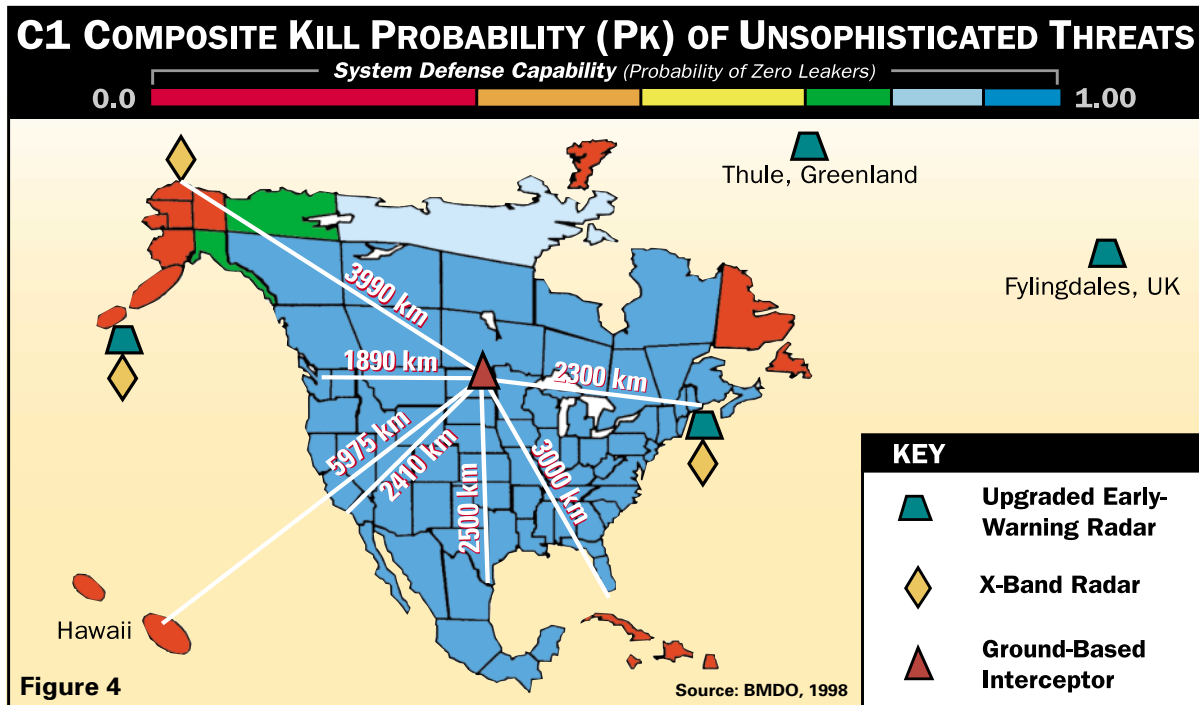
This proposal suggests that if the United States established a missile defense system at Grand Forks, North Dakota, as permitted by the treaty, it could unilaterally interpret those portions of the treaty that might be violated by a strict interpretation of the document. For example, Article 1, Clause 2, prohibits the establishment of a national missile defense. Some have stated that a missile defense that could defend all fifty states against a very limited rogue-state attack is not actually a national missile defense, since Russia could easily overwhelm this capability.²³ Likewise, the prohibition of radar use in an ABM role could be circumvented by routing the information through the U.S. Space Command rather than providing it directly to the NMD Battle Management Center.

This approach would allow the United States to begin work on its land-based NMD system in Summer 2000 in the event that an agreement is not reached with Russia to modify current treaty provisions. The drawbacks, however, are these:

- As can be seen on the map depicted in figure 4, the United States can only defend the contiguous forty-eight states from Grand Forks, North Dakota. To defend Alaska and Hawaii would

²² Bryan Bender, "Interview: Robert Bell," *Jane's Defence Weekly*, 18 August 1999, 40.

²³ Robert Bell, National Space Foundation's Annual Space Symposium, Colorado Springs, CO, 10 April 1998.



require the use of a theater missile defense system that would not have been tested against an ICBM-level capability. This will likely prove to be unacceptable to the residents of Alaska and Hawaii.

- If the United States interprets the ABM treaty unilaterally, in ways that are clearly designed to circumvent the agreement, Russia will undoubtedly complain loudly. Such a situation could encourage other countries, as parties to treaties that they find too binding, to follow suit. Even significant segments of the U.S. public, which generally see the United States as an honorable country, may also take umbrage at such a course of action.

Based on the problems cited, this proposal seems to have lost most of its support over the course of the last year. A single-site defense from Grand Forks will not meet the provisions of U.S. law which requires that all fifty states be defended.

Consequently, the administration has recently signaled that it is aiming for a single-site defense to be based in Alaska.²⁴

The state of ABM treaty modification negotiations

Talks between Russia and the United States on the emerging missile threat (as outlined in the 1999 U.S. National Intelligence Estimate) and on the U.S. desire to modify the ABM treaty, continued into March 2000.²⁵ The official U.S. approach has been to support ABM treaty changes to the extent that they do not jeopardize the overall arms control regimes with Russia.

The Russians have continually rejected any modification of the ABM Treaty.²⁶ A number of high-level Russian officials and security-related personnel have made firm statements declaring that if the United States deployed a national missile defense,

²⁴ "Alaska Likely To Be Site of U.S. Missile Defense System," *Xinhua* (Beijing), 9 September 1999.

²⁵ F. M. Ivanov, "Moscow Rules Out Changes in ABM Treaty," *Agence France Presse*, 21 September 1999; and "Russia, U.S. Fail To Narrow Gap On ABM Positions," *Interfax* (Moscow), 22 December 1999, transcribed in FBIS; and "U.S. Proposed ABM Revision Not Negotiable," *Interfax* (Moscow), 3 March 2000, transcribed in FBIS.

²⁶ For examples of Russian positions on the ABM treaty issue see, "Russia Willing to Work On START III if ABM Treaty Left Unchanged," *Associated Press*, 4 September 1999; Russia Not Engaged In Talks with USA On ABM Treaty-Official," *ITAR-TASS*, 18 February 1999; Anatoliy Yurkin, "US Decision to Deploy ABM System Will Upset Stability," *ITAR-TASS*, 16 August 1999; "US ABM System Will Infringe Interests," *RIA* (Moscow), 19 August 1999; and "Russia to Upgrade Strategic Rocket Forces If U.S. Forms ABM System," *Xinhua* (Beijing), 19 August 1999.

Even if Russia could destroy most of the U.S. land-based nuclear forces, it is not in a position to exploit that success by seizing Western Europe. It is also not capable of destroying the U.S. submarine-based nuclear strike force.

– p. 2.9

Russia would upgrade its strategic nuclear forces and take other steps as well.²⁷ General Vladimir Yakovlev, commander in chief of Russia's Strategic Missile Forces, in a December 1999 interview (just before President Yeltsin's resignation), stated that his command was prepared to propose the following countermeasures if the United States deployed an NMD system:

- Extend the life of the UR-100N ICBMs [SS-19s] for thirty years. The missile would remain equipped with six reentry vehicles.
- Equip the *Topol M* (SS-27) ICBMs with multiple reentry vehicles [author's note: probably three RVs].
- Use the same MRV-equipped missile technology (SS-27) for both naval and ground forces (a cost-saving measure).²⁸
- Introduce advanced technologies for future *Topol M* missiles to include improved warheads and countermeasures, maneuvering warheads, and gliding winged warheads that have a low radar and optical signature.²⁹

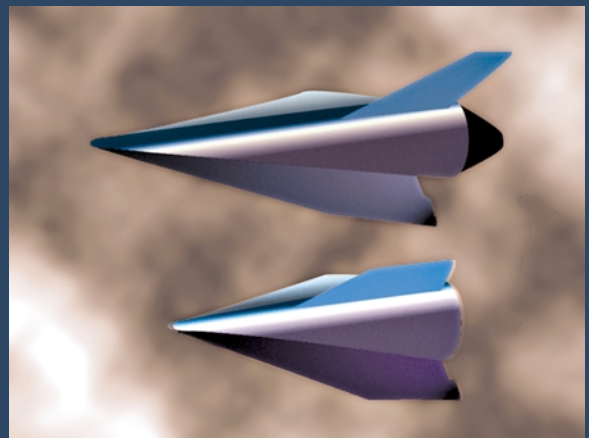
It should be noted that Russia is already implementing some of General Yakovlev's proposals. The SS-27 does maneuver en route to its target, and it does incorporate advanced penaids. The gliding winged warhead he mentioned is possibly the Project X system described in IFPA's 2010 study (see figure 5).³⁰ Although Russia could execute some of the actions described by General Yakovlev, doing so would require significant sacrifice by Russia to execute all of them. Even with sacrifice, it is not clear whether Russia could afford the entire program. However, the plan that Gen-

eral Yakovlev described likely represents the Russian military's preferred course of action if the U.S. were to deploy an NMD system.

At the political level, however, it is likely that Russia will try to use U.S. interest in START II entry into force and ABM treaty modification desires to attempt to maneuver the United States into agreeing to highly restrictive limits on future U.S. strategic forces and missile defense capabilities. It seems apparent that Russia wishes to drive down U.S. strategic force limits to under 1500 warheads (some are calling for a limit of 1000), it wants any missile defense system that the United States deploys to remain modest, and it seeks U.S. agreement to MIRV the *Topol M* (SS-27) ICBM.³¹ These objectives support Russia's goal of undermining U.S. power and reestablishing Russia as a major world power within a multipolar structure.

If the United States agreed to a limited MIRV capability on land-based missiles, it would mean that Russia would be able to keep more warheads fielded than would be the case under START II (given its current missile production limitations).

Project X: Winged Warheads



Unconfirmed Soviet project to develop a warhead that could be orbited during a crisis and fly to its designated target on command.

Figure 5

²⁷ "Russia to Upgrade Strategic Rocket Forces If U.S. Forms ABM System."

²⁸ General Yakovlev claims that Russia plans to reduce the current six models of strategic missiles being operated to a single common system based on the *Topol M*. He claims that such a move will reduce operating and maintenance costs by 30 percent; Grigoryev, "CINC Yakovlev Interviewed on 40th Anniversary of RVSN."

²⁹ Ibid.

³⁰ "Assessing U.S. Missile Defense Requirements in 2010," 2.6.

³¹ Mikhail Shhevtsov, "Sergeyev Says START II Can Be Ratified Before March Poll," *ITAR-TASS*, 12 January 2000, transcribed in FBIS; and "Key Duma Member Believes Russia Will Agree To ABM Treaty Changes," *Inside Missile Defense*, 12 January 2000.

Convincing the United States to reduce its START III warhead ceilings to a level below 1500 warheads would also reduce the United States' strategic capabilities to a level that could be challenged by China's potential warhead production capacity. Since a bilateral agreement would only apply to Russia and the United States, it would do nothing to slow proliferation activities around the globe and it could contribute to the emergence of additional centers of power capable of asymmetrically challenging the United States' military capabilities.

Russia's apparent preferred outcome to the ABM and START II issues outlined above would bind the United States in a bilateral agreement at a time when the world is changing dramatically. If the United States entered into such an agreement without any accompanying restrictions on Russian, Chinese, and North Korean global proliferation activities, or on the strategic development programs of states such as China, the United States could find itself in an increasingly precarious security situation.

Understanding NMD Technology

Much of the current debate on NMD is about technology. Because NMD has not yet been deployed and some of its key components are not yet fully developed and tested, critics have maintained that such a system cannot be effective because countermeasures can be designed to penetrate any defensive system that the United States is likely to field. At the same time, some supporters of NMD have asserted that necessary technology, if it does not yet exist, is nevertheless within reach. Others have claimed that the technology already exists but needs to be integrated into a missile defense system and deployed as quickly as possible.

As a result of such issues and challenges, the policy community has been engaged in a debate that encompasses technical questions outside the boundaries that normally delineate strategic policy deliberations. In order to dispel some of the technological controversy surrounding the missile defense question, it is necessary to survey the technologies being developed for the NMD

system. Without such understanding, it is difficult for decision makers and the broader policy community to make informed judgments on the feasibility and potential effectiveness of the various NMD options under discussion.

Since the effectiveness of the NMD system will be highly dependent upon sensor technology and target array discrimination, the purpose of this chapter is:

- First, to survey the potential target array confronting the NMD system.
- Second, to examine the technical capabilities of the various land-based NMD components, first reviewing the systems that use common sensor technologies in the target detection and discrimination process, then shifting focus and looking at the other supporting NMD technology elements.

Because the bulk of the missile defense research and development to date has been undertaken by the



army and the Ballistic Missile Defense Organization (BMDO), this chapter focuses on the technology being developed for a land-based system. However, if the United States should decide in the future to deploy a sea-based NMD capability, much of the technology being developed for the land-based system could be adapted by the navy for use at sea. (Some of these issues will be addressed in chapters 4 and 5.) Thus, **regardless of basing mode, the technologies discussed in this chapter are applicable to all terrestrial NMD options.**

The potential target array

Since, as noted in chapter 1, almost all ICBMs emerging during the next decade are likely to incorporate at least some missile defense penetration aids (penaids),¹ the sensor technology must be able to sort out the objects in a target array that can include sophisticated jammers and electronically enhanced decoys. An ICBM travels to its aim point in three distinct phases: boost phase, midcourse, and terminal phase. For national missile defense, the boost phase and midcourse are the key phases of interest.

The boost phase

The boost phase starts at the time the missile is launched and ends when the final stage of the booster system completes its burn. The total booster burn time for an ICBM typically lasts between three and six minutes (180 to 360 seconds), depending on the type of fuel used and the acceleration capabilities of the missile's design (that is, boosting and turning stresses as versus structural strength). As a rule, solid-fueled systems tend to spend less time in boost phase than do liquid-fueled missiles, since solid-fueled systems accelerate faster. For missile defense architectural planning, faster ICBM flyouts mean that there is less potential time to destroy a missile while it is in boost phase before the missile's complex payload is deployed.

Obviously, if the missile can be destroyed or disabled before it achieves its programmed velocity, it will not reach its planned target area (even if a disabled missile's momentum continued to carry the payload along a ballistic trajectory, the payload would fall short). Boost-phase intercepts also allow the defenses to avoid the problem of target array discrimination and the potential requirement to intercept multiple warheads from a single missile, a problem that plagues mid-course intercept planning.

However, intercepting an ICBM during boost phase is difficult, not only because of the limited time available to do so, but for other reasons as well. When an ICBM is launched, it rises straight up from the earth's surface for perhaps fifteen seconds, then begins to arc in the general direction of its intended trajectory. While the missile is still being boosted, missile defense systems cannot determine the number of degrees the missile will turn as it ascends, or what its velocity will be at booster burnout, data elements needed to determine how far downrange the missile will fly. In the absence of other information, the defenses will not be able to determine if the missile is aimed at a target 4000 or 10,000 kilometers away until nearly the very end of this phase. It will also be unable to target the missile using sensors developed for midcourse engagements because those sensors will be unable to "see" the booster in the midst of all the flame.

Each stage of the boost phase is marked by the missile's acceleration, a pause in the acceleration rate in order to drop a spent stage, and then renewed acceleration at an ever increasing rate as fuel consumption lightens the missile and stages are dropped. The resulting pattern is much like a standard-shift automobile taking off from a stop light. This jerky pattern makes it more difficult for defenses to make a boost-phase intercept because the acceleration rate is not a constant, which complicates the targeting problem. As an added challenge, complex missiles, such as Russia's SS-18 and SS-27, can

¹ The 1999 National Intelligence Estimate assessed that emerging missile states will probably have penaid technology by the time their ICBMs are developed. The implication of that claim is that the U.S. NMD system must have some capability of dealing with penaids.

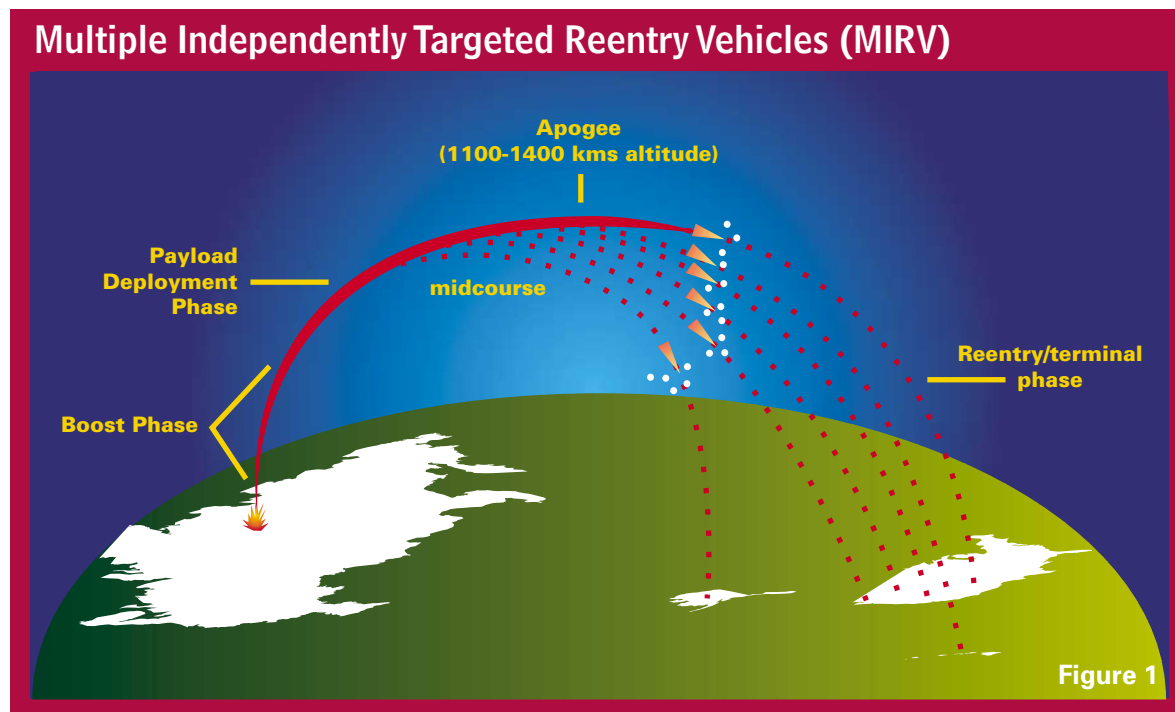
also change direction during the boost phase. Although the specifics of each missile and launch profile will yield a different answer, **an ICBM normally will be located between 300 and 800 kilometers downrange from its launch point, and be at an altitude of 200 to 600 kilometers above the earth at the time the boost-phase burn is finished and the payload package is injected into its elliptical ballistic trajectory.**

The time and location constraints make it very difficult to use a missile for the boost-phase intercept mission. In order for the United States to use missile technology successfully in boost-phase intercepts, the intercepting missile would have to be able to reach the downrange boost-phase window within a reaction time of roughly two to three minutes. The intercepting missile would need a very fast acceleration and flyout velocity in the vicinity of 8 to 8.5 kilometers per second (kps) if it is to have a cost-effective intercept footprint.² It would also have to be linked to a sensor system capable of providing target position updates on a continuous basis while controlling the intercept geometry. The only missile defense systems currently being considered that have a great poten-

tial for destroying a missile during its boost phase are the Airborne Laser (ABL) and the Space-Based Laser (SBL) technology demonstrator.

The midcourse and the target array

Once the booster system delivers the payload package to a predetermined point in space and at a specified velocity, the final booster stage drops off and the payload package enters the midcourse phase of the trajectory. The payload package can be very simple, essentially just a warhead, or it can include a post-boost-phase vehicle (PBV), often informally referred to as a bus. The bus is a small missile stage and RV mounting rack that carry the payload after burnout, correcting the midcourse flight path and ejecting RVs and pen aids at programmed points along the trajectory. Most often these programmed points are on the ascending leg of the bus's trajectory, and the payload is entirely dispersed by the time the trajectory's apogee is reached (see figure 1).



² Scientists who have explored this issue in depth found that boost phase intercepts with a potential range of 800 to 1000km require specific basing locations and missile flyout velocities between 8 to 8.5 kps. Without the fast flyout, the missile has less speed and divert velocity to make the intercept.

As the sophistication of the ICBM increases, so does the complexity of the target array. In general, the types of objects that can make up a mid-course target array include:

- **Decoys.** These could include metal-coated balloons, tethered balloons that could help shield the RVs or enhance the signature of a decoy, or lightweight inflatable or rigid replicas

that would look like reentry vehicles (RV) to sensor suites, but be much lighter so as not to degrade offensive missile payloads. More advanced decoys could include an infrared source that matches the infrared brightness of a reentry vehicle. For example, a recent Russian article claims that with the latest upgrade, Russia's formidable heavy-lift ICBM, the SS-18, now incorporates 40 targets in its payload (which in conjunction with other reports indicates that along with 10 reentry vehicles, about 30 reentry-vehicle decoys and over 1000 other objects are deployed as part of

the SS-18 warhead package.)³

- **Signature alteration, stealth, and chaff.** A warhead designer can alter the signature of a reentry vehicle by reducing the infrared signal (by employing, for example, special paint or cooling techniques that could include the use of cryogenic gases) or by incorporating stealth design technologies to reduce the radar cross section. This effort could include packaging the reentry vehicles inside metal-coated balloons to mask their shape and infrared signature.

For example, the United Kingdom developed decoys and altered the signature of its RVs during its 1970s- and 1980s-era *Chevaline* warhead development project. Reports incorrectly

Routine Launch Debris

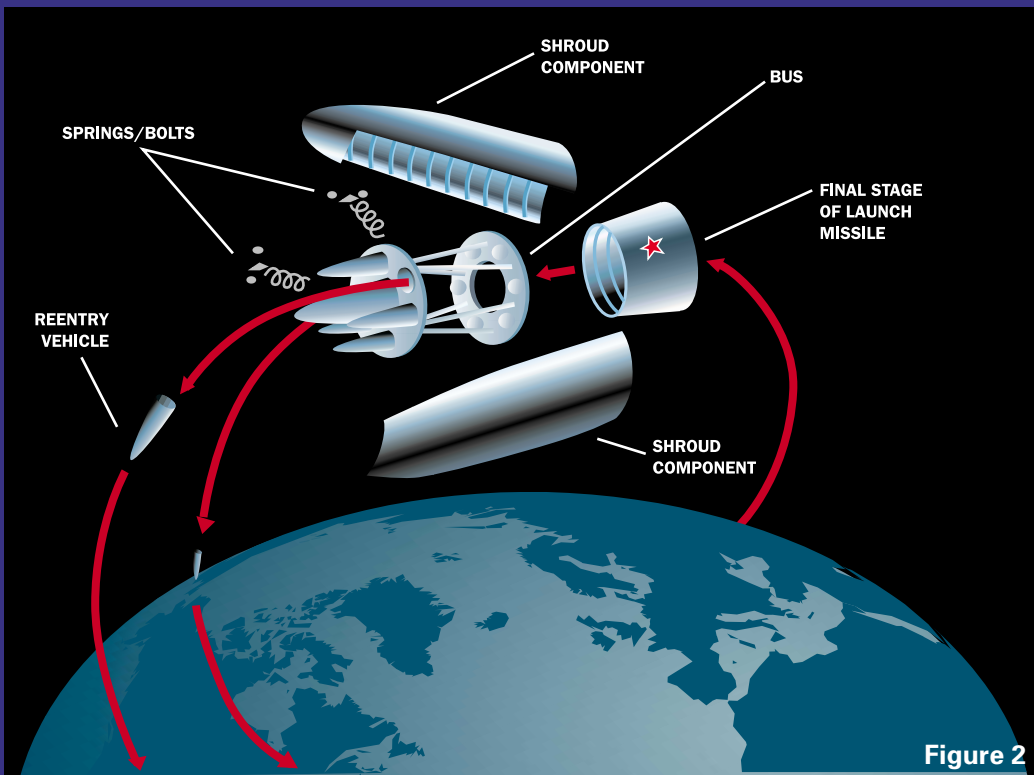


Figure 2

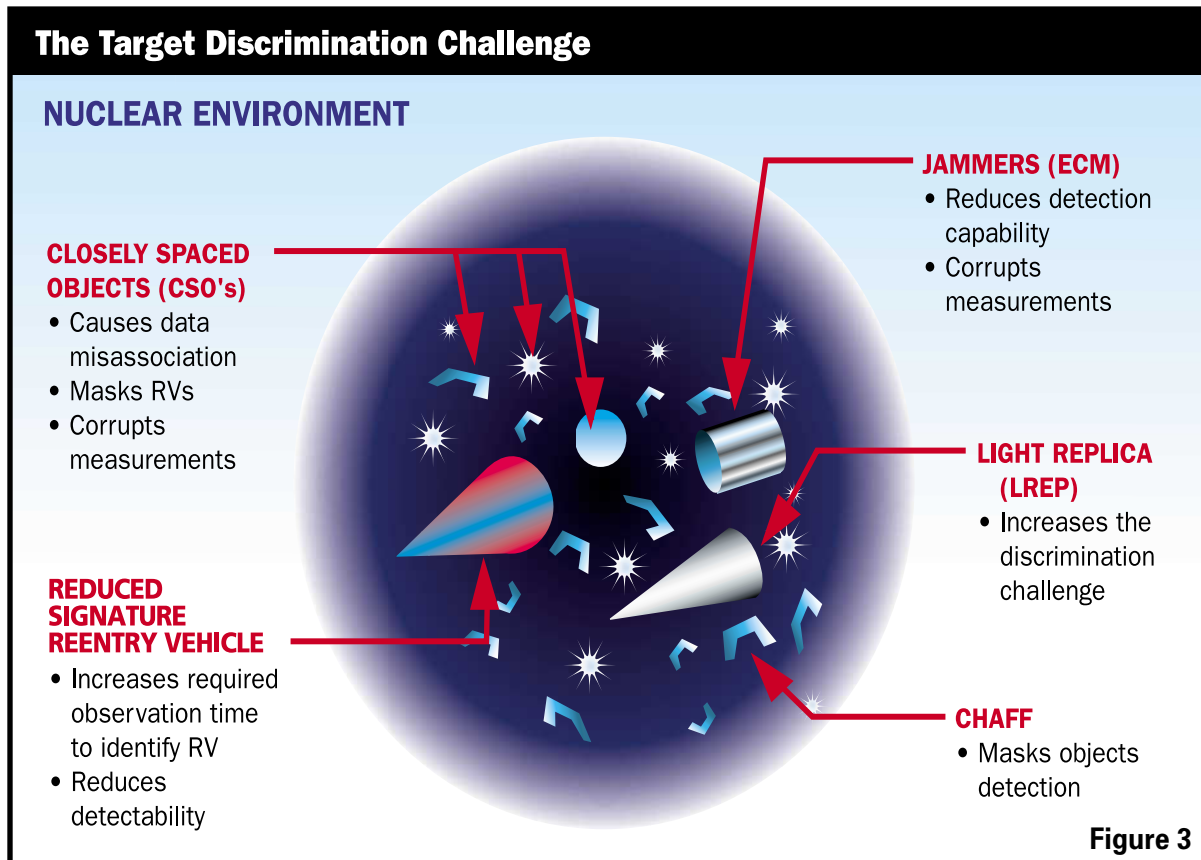
- **Launch debris.** All missile launches include a certain amount of debris that accompanies the reentry vehicles during the exoatmospheric portion of the flight path (the portion outside the earth's atmosphere, primarily the mid-course phase). Debris can include such items as the booster (which might be explosively segmented to increase the number of hot objects accompanying the RV, each emitting high levels of infrared radiance), shroud components (if used), the expended bus (if used), springs that help to detach reentry vehicles from the bus, and assorted explosive bolt parts. Even without penetration aids, the defense system must be able to discriminate between the lethal objects and the non-lethal objects in such an array (see figure 2).

³ Vladimir Krylov, "ABM Trap: Why Is the U.S. President Trying To Revise the 1972 Unlimited Duration Treaty?" *Sovetskaya Roossiia* (Moscow), 23 February 1999, p. 2. In addition, a 1997 Russian newscast claimed that the SS-18 deploys over 1000 objects along with its payload package.

claimed that the U.K. packaged its reentry vehicles inside gas-filled metal-coated balloons. In reality, many 10s of decoys were created and the reentry vehicles were altered to provide the same radar signature as that of the decoys.⁴ It may have been that an umbrella-like object was attached to the front of all reentry vehicles and decoys to shield them from radar scrutiny. Note that even with the help of the U.S. defense industry, the U.K. experienced considerable difficulties mastering this technology during a thirteen-year development program. The decoys displaced one reentry vehicle in each warhead deployed.⁵

Finally, chaff can be released with the reentry vehicle in a simple attempt to hide the target array behind a cloud of radar-reflecting metal strips (see figure 3).

- **Active jammers.** These include small transmitters that broadcast a signal that interferes with a radar's ability to detect the target object or corrupts the signal in such a way as to cause the radar to receive a false echo (by amplifying, elongating, and re-broadcasting the signal). Jamming capabilities are included in Russian missile-system payloads and are likely incorporated in modernized Chinese missile systems.⁶
- **Salvage fusing.** Warhead designers may equip a nuclear warhead to detonate if it is struck while en route to its target. The resulting thermal energy, nuclear radiation, and an electromagnetic pulse effects could disrupt sensor systems whose function is to track other warheads involved in the attack. Space systems in low-earth orbit are particularly vulnerable



⁴ The account that the reentry vehicles were packaged inside balloons was reported in Robert S. Norris, Andrew S. Burrows, and Richard Fieldhouse, *Nuclear Weapons Databook: British, French, and Chinese Nuclear Weapons*, vol. 5 (Boulder, CO: Westview Press, 1994), 112.

⁵ Stanley Orman, "Defeat of Missile Defenses Not As Simple as Portrayed," *Defense News*, 13 December 1999; and subsequent private conversations.

⁶ Krylov; and Institute for Foreign Policy Analysis, *A Prognosis for International Missile Developments in 2010* (Washington, DC., August 1997), 8-10. Furthermore, public comments made by senior military officers soon after China fired DF-15 (M-9) missiles into the Taiwan Strait in March 1996 hinted that the missile system incorporated active penetration aids. If so, these types of penaids are also likely to be incorporated into the payload of any new Chinese ICBM warheads.

to these exoatmospheric (outside the earth's atmosphere) nuclear detonations. It should be noted that experts disagree as to whether or not a salvage fuse can react quickly enough to make an ICBM warhead explode before its integrity is destroyed by a hit-to-kill interceptor. However, the general designer of the Russian anti-ballistic missile system stated that, as a rule, attacking warheads are equipped with sensors that detonate the nuclear charge if they are struck.⁷ Thus, it appears that salvage fusing is likely to be incorporated into the design of many of the nuclear warheads that NMD interceptors could engage.

The terminal phase

As the target array begins to reenter the earth's atmosphere at an altitude of about 100 kilometers, the reentering objects heat up (creating a bright infrared signature) and the light decoys are stripped away from the reentry vehicle(s). Between 40 and 80 kilometers above the earth's surface, these warheads will still be traveling very fast, but on a predictable trajectory. As the atmosphere begins to thicken below 40 kilometers, the RVs can begin to make aerodynamic maneuvers or spirals, making them difficult to hit. Currently, the United States has no NMD programs for terminal-phase intercepts.

Note that a *Patriot* point defense system or its equivalent is too slow to destroy an ICBM reentry vehicle in the terminal phase, even one headed directly for its location. A Theater High-Altitude Area Defense (THAAD) missile might be successful at intercepting such a target, especially at an altitude of 40 to 80 kilometers, the so-called missile defense "sweet spot." In this window, the decoys have been negated by the atmosphere, but the air is not yet thick enough for the RV to perform aerodynamic maneuvering. Unfortunately, THAAD's slow flyout velocity (part of the administration's ABM treaty demarcation initiatives) reduces its potential intercept probability

against targets traveling at ICBM speeds (a delta-V issue that will be discussed later in this chapter)

Other payload options

The preceding discussion focused on nuclear payload packages. However, it is becoming increasingly clear that future payloads could also consist of dozens or hundreds of bomblets, each filled with chemical or biological agents. While these bomblets could be loaded into a carrier that subsequently dispersed the bomblets when over the target area, a second option is to release these submunitions early in the missile's ballistic trajectory, thus creating multiple targets for interception. Although a chemical agent attack might inflict hundreds of casualties, it would not be nearly as devastating as an attack using biological agents or nuclear weapons.⁸ Consequently, it is the biological threat represented by these bomblets that is of major concern to defense planners. Unfortunately, early-release submunitions cannot be defeated by unitary hit-to-kill interceptors.

Sensor systems: the critical technologies for midcourse intercepts

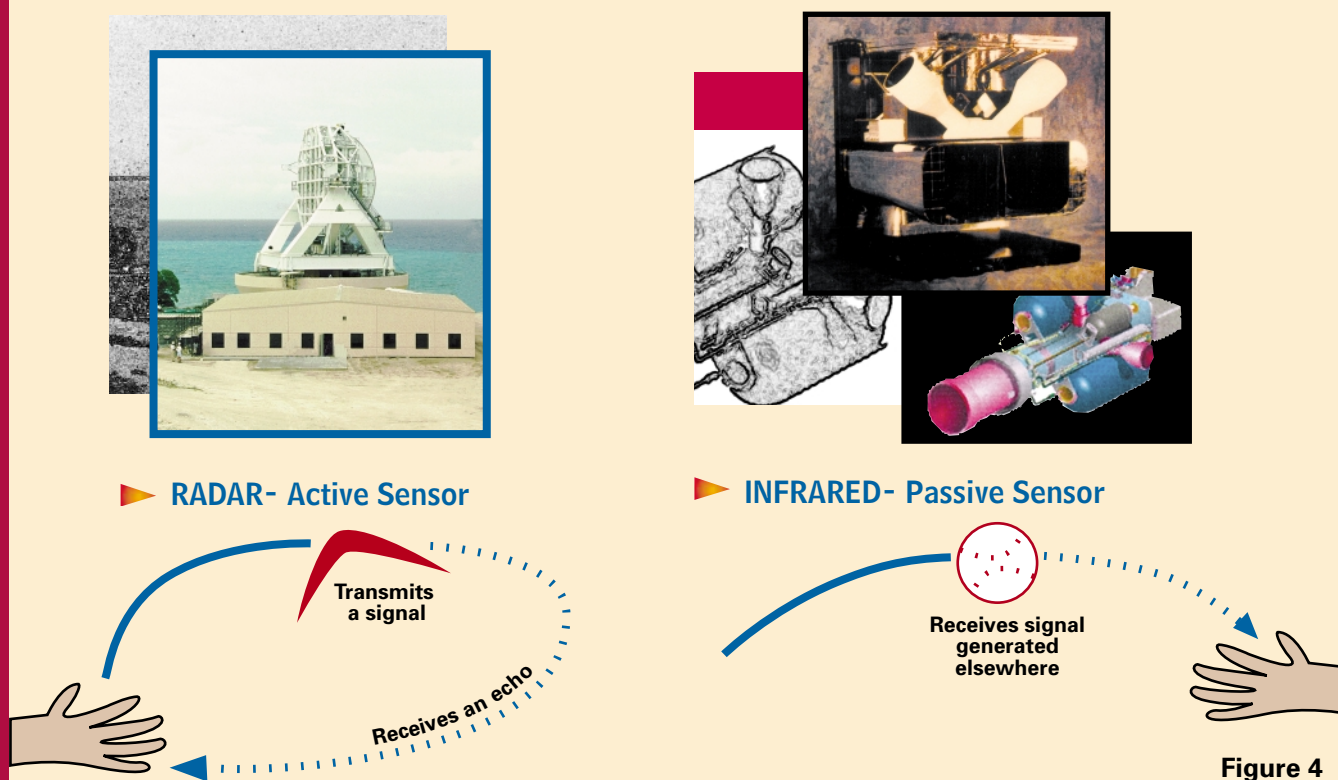
Effective sensor suites with the capability to discriminate among the various objects in a hostile target array are central to the NMD issue. Dr. John Peller, Boeing's NMD lead-system integrator program manager, characterized the NMD system during Senate testimony, as "a large collection of sensors [and] a computer system that links it all together."⁹ His statement underscores the mission of NMD: to "sense" and discriminate the target array, process the data and steer the intercept electronically, and keep a human decision maker in the loop. Of these three processes, the capabilities of the sensor systems are the most controversial aspect of the NMD program.

⁷ "Point, Counterpoint on Need for ABM Development: Interview With Antoliy Georgiyevich Basistov, General Designer of the A-135 Moscow ABM Defense," *Itogi* (Moscow), 21 August 1997, translated in FBIS-SOV-97-232. Salvage fusing was also discussed in U.S. Department of Defense, Summary of Report to Congress on Utility of Sea-Based Assets to National Missile Defense, prepared by the Ballistic Missile Defense Organization, 1 June 1999, 15. The report attributed salvage-fusing capabilities to third world nations.

⁸ IFPA, "Exploring U.S. Missile Defense Requirements in 2010," pp. 2.18, 5.8, 5.9. Study is posted on the Internet at www.inpa.org.

⁹ Dr. John Peller, testimony before the Subcommittee on Strategic Forces, Senate Armed Services Committee, 24 February 1999.

Radar & Infrared: The Active & Passive Sensors of the C1 NMD System



The NMD system will have both active and passive sensors, as described below and illustrated in figure 4.

- **Passive sensors** do not transmit any signals, they simply detect naturally reflected or emitted electromagnetic waves from objects within their field of view. Infrared (IR) sensors, one of the key technologies in the NMD program, are passive sensors. A single infrared sensor can detect the direction from which an infrared signal was received (two dimensions, the horizontal and vertical angles), but it cannot determine the distance to the emitting object. Infrared sensors can detect range-to-target distance only if they are employed in pairs or in sets of more than two sensors that permit signal intersection, triangulation, or stereoscopic observation.
- **Active sensors**, such as radar systems, transmit an electromagnetic wave that is reflected from

all objects within the search field. The microwave radars used for NMD determine an object's location in three dimensions: horizontal angle, vertical angle, and range, with range being the most accurate measure.

Infrared sensors form the heart of the Defense Support Program (DSP) satellites, the Space-Based Infrared System (SBIRS)-High and SBIRS-Low, and the exoatmospheric¹⁰ kill vehicle (EKV). Infrared systems detect, track, and capture images of the potential missile threats or their target arrays.

Initially, all radar sensors will be ground-based systems. The current early warning radar network will be upgraded and a new ground-based X-band radar system will be fielded to provide the active sensor elements. If or when the next generation of NMD capabilities is implemented, (the so-called C2 architecture), it is possible that a laser radar might be added to some of the exoatmospheric NMD sensor platforms.

¹⁰ Exoatmospheric means outside the earth's atmosphere.

INFRARED TUTORIAL

Infrared (IR). The invisible light waves composed of wavelengths slightly longer than those forming the color "red" in the visible portion of the electromagnetic spectrum are labeled infrared. Every type of object radiates a unique infrared signature or "fingerprint," a positive object identification can be made by measuring the curve of the received energy. The IR energy received will contain various electromagnetic wavelengths that are classified as short, medium, long, and very long. As can be seen on the graph, the peak intensity of IR radiation follows a pattern:

- very hot bodies radiate high quantities of short-wave infrared (SWIR: 1-3 microns)
- warm bodies radiate significant quantities of medium-wave infrared (MWIR: 3-8 microns)
- cold bodies predominantly radiate long-wave infrared (LWIR: 8-14 microns)
- very cold bodies radiate very long-wave infrared (VLWIR: 14-30 microns)

Unfortunately, for IR sensors (those materials that react to electromagnetic wavelengths in the IR spectrum) to detect cold-body objects, their focal plane arrays must be cooled to depress their own IR signatures (noise). For national missile defense, cryogenic cooling is required to enable detection of long-wave infrared signals. As an added problem, any attempt to detect cold-body objects must be

accomplished from an angle that excludes the earth or the sun from being in the background. Because those objects radiate so much infrared energy, they swamp a sensor's ability to detect the low intensity IR signals radiated by cold-body objects.

For national missile defense, infrared sensors can be used to detect the hot flame of a missile launch (short and medium-wave infrared), the initial direction that a warm missile is traveling immediately following burnout (medium infrared), and midcourse tracking of cold objects in a target array (long infrared). The larger the mass of the object, the more slowly it cools in the near absolute zero temperatures of space. Thus, a uranium or plutonium-filled reentry vehicle in midcourse will cool to a temperature in the range of 280-330° K (273.16° K = 0° C), thus emitting an IR signal that is stronger than that of a metallic-coated balloon, for example, which will have cooled at a faster rate. By viewing the target array in two or more parts of the IR spectrum, one can determine the relative temperature of a family of objects as well as derive the relative masses of the objects in the array. Without two- or more-color sensing, temperature cannot be determined. Only the brightness of an object which could have been increased by treating an inflatable decoy with a thermal-producing chemical reactant. As a result, multicolored IR sensing is a key factor in discriminating or determining the midcourse target array.

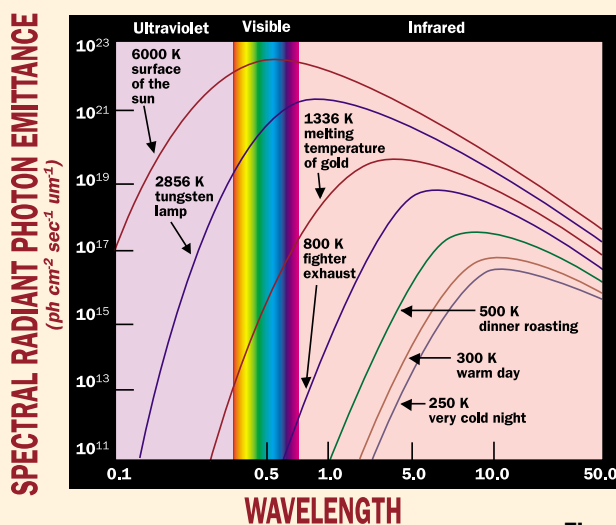
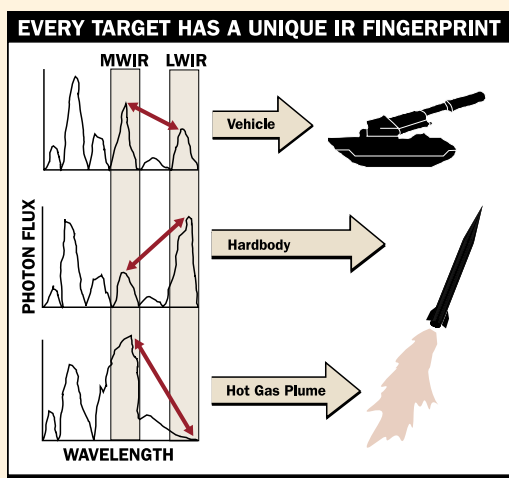


Figure 5

These sensor technologies are a key factor in the NMD technical debate. As will be shown in chapter 5, some proposed alternatives to the current program are not very feasible in the near term, because of technological limitations. As a preface to the discussion in chapters 4 and 5, the remainder of this section provides a layman's review of infrared technology and the NMD systems that incorporate that technology, followed by the same treatment of radar technology and systems.

Note that this discussion does not present the whole story on sensor technology. When asked about some of the claims anti-missile defense experts were making regarding how easily radar and infrared can be fooled, one MIT Lincoln Laboratory radar scientist noted that the people making these claims are not fully informed about modern radar capabilities. Advanced techniques do exist for handling the counter-radar capabilities, but for the NMD developers to reveal those secrets would be self-defeating – it would expose those capabilities for counteraction by penaid engineers.

In another case, the author was in a conversation with a retired technical expert who had been involved in a SDIO (Strategic Defense Initiative Organization, BMDO's predecessor) infrared sensor test and accidentally learned of some reentry vehicle phenomenology that greatly assists defense planners in discriminating reentry vehicles. In the interest of U.S. national security, that information has not been included in this report. Undoubtedly, there are other classified countermeasures for dealing with many (but not all) of the penaid capabilities hypothesized by NMD foes.

How infrared sensors work

All objects in the universe emit infrared electromagnetic-wave patterns. These patterns, when measured across the infrared frequency spectrum (that is, in different electromagnetic wavelengths or frequencies), can be used to identify the unique IR "fingerprint" of each object in the sensor's field of view. The ability to measure an object's IR signature in at least two or more wavelength bands is a crucial factor in the mid-course target-array discrimination process. Note

that some proposed alternative NMD systems have only single-color IR sensors.

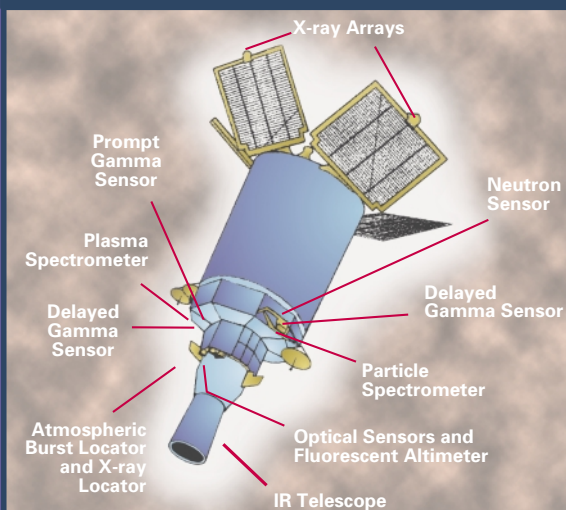
Under normal circumstances a reentry vehicle, when exposed to the frigid temperatures of space, will retain more heat than metal-coated balloons and light-weight decoys since the RV has much greater mass. Consequently, the target-array object with the highest degree of infrared radiance (the greatest quantity of IR emissions) normally will be the reentry vehicle and, thus, the target.

Even so, it is the cold-body detection requirement that poses one of the major challenges for NMD detection and targeting. The levels of infrared radiance emitted by an object become increasingly faint as its temperature drops, which in the case of missile payloads means that the longer the target array remains outside the earth's atmosphere the fainter its infrared signature becomes. The simple fact that intercontinental warheads are in the deep freeze of space for longer periods than are the payloads of shorter-range missiles means that the IR target-detection challenge is greater for ICBMs.

As an additional complication, offensive missile engineers can alter the normal IR signature of a target array by, for example, inserting flares into the array to generate a more intense IR signal than the one emitted by the reentry vehicle. Engineers can also use some of the techniques discussed earlier to lower the IR signature of the reentry vehicle or to heat the decoys and increase the intensity of their IR signature. If an exoatmospheric kill vehicle were to be equipped with only a single-color IR sensor, it could be decoyed fairly easily since the interceptor would tend to go after the most intense IR source in the target array (with some possible calculation of other parameters).

However, it becomes much more difficult to decoy the kill vehicle if the kill vehicle is equipped with a multicolored IR sensor. With a multicolor sensor, emitted infrared readings can be measured on different parts of the IR spectrum to plot their curve, as shown in the bottom charts of figure 5. These IR measurements can be analyzed to determine the approximate temperature and IR fingerprints of the various objects in the target array, making it more difficult for offensive missile engineers to

Defense Support Program (DSP-1) Satellites



Constellation: Established in 1971; renamed DSP-1 in 1989 and upgraded to 4 satellite constellation

Orbit: Geostationary, along the equator at 35,787 kms altitude

Primary missions: Monitor nuclear detonations and missile launches

Missile detector: 12 ft. infrared telescope, mounted at a 7.5° angle, and measures short and medium wave IR

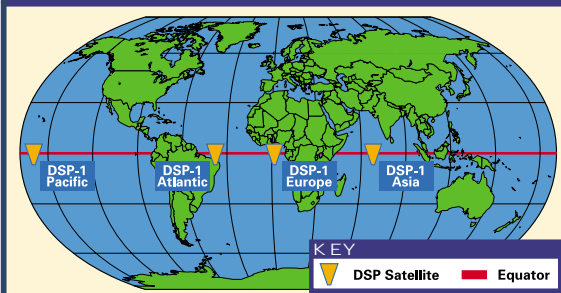
IR scan rate: Pattern search, revisit rate every 10 seconds

Resolution: 3 km

Detection capability: Missiles in boost phase, gas-well flames, and large fires



Location of DSP-1 Constellation (1990)



Sources: Jane's Defence Weekly, July 30, 1997; Richelson, America's Space Sentinels, 1999; USAF Space and Missile Systems Internet Site; Forecast International; Lockheed Martin; Smithsonian Institution; and NASA

Figure 6

develop penetration aids capable of decoying missile defense systems, since the decoy would have to be capable of replicating the warhead's changing spectrum ranges all along the midcourse trajectory. Although not an impossible task, this adds significant difficulty to penaid engineering.

The IR-based systems that make up the NMD program are discussed below.

High-altitude space-based infrared sensor systems

The current Defense Support Program (DSP) satellite system and its planned replacement constellation, the Space-Based Infrared System-High (SBIRS-High), provide – or will provide – the United States with the initial warning that a missile has been launched. Since these systems are located over 22,000 miles above the earth, they only detect and track missiles that are in the boost phase and generating hot plumes of intense infrared radiation. Since the earth itself emits massive quantities of IR radiance, only very intense short-wave IR signatures can be identified at these long distances.

Once the high-altitude sensor satellites report that a missile has been launched, the U.S. Space Command alerts all other potential collection assets to the approximate location of the missile. Early-warning radar systems and reportedly any other intelligence-collection capabilities available focus on the missile to determine the missile's point of origin, trajectory, model type and capability, number of reentry vehicles, and projected impact point(s).¹¹ Unfortunately, as will be shown, the initial alerting system is not capable of providing all of the information needed by a missile defense system to intercept the missile.

The DSP satellite constellation

Since the Defense Support Program was first launched in 1971, a lot of information about this

¹¹ Although the methods by which this coordination occurs are somewhat obscure, it is clear that many different space and ground systems are activated to examine missile data when the high-altitude alert system reports a missile launch. See U.S. Air Force Space and Missile Systems Center, Los Angeles AFB, "Space Based Infrared System, SBIRS," *SBIRS Program Office Booklet*, undated, 16; and Zhang Zhaozhong "Resurgence of the Star Wars Program: How Can Ballistic Missiles Be Countered?" *Jiefangjun Bao* (Beijing), 7 February 1999, 4, translated in FBIS.

system has become public knowledge. DSP thus provides a good starting point for learning about infrared sensor capabilities.

The DSP satellite constellation consists of four satellites stationed 35,787 kilometers above designated points along the equator. The primary mission of the DSP constellation is to monitor intense infrared sources that could be generated by the plume of a missile in boost phase; it also reports on space launches, other intense infrared activity, and nuclear detonations.¹²

Since its establishment, 23 DSP satellites have been built,¹³ 20 of which have been launched. Beginning with the launch of the fourteenth satellite in 1989, the DSP constellation was upgraded substantially, renamed DSP-1, and expanded from a 3-satellite constellation to a 4-satellite system.¹⁴ A system of 4 satellites in geo-stationary orbit permits 2 satellites to view any missile launch. Two systems tracking the missile provide the stereoscopic observation needed to build a more accurate track of the missile's initial trajectory.¹⁵ As noted earlier, a single IR sensor cannot determine range, but two IR sensors observing the same event from different points correct that shortcoming.

DSP satellites have a life expectancy of five years; DSP's lead-sulfide (PbS) short-wave IR detectors were expanded from 2000 sensor cells on the DSP design to 6000 cells on DSP-1, improving target position accuracy from 6 kilometers to 3 kilometers.¹⁶ The new satellites are also protected from blinding by ground-based lasers and have been given limited maneuverability for avoiding anti-satellite weapon systems.¹⁷ At the same time a mercury-cadmium-telluride (HgCdTe) focal plane

was added to the sensor suite in order to detect medium-wave infrared signals above the horizon, against the background of space.¹⁸ Before the addition of medium-wave IR, the DSP system could not track many second-stage burns or missile tracks against the backdrop of space.¹⁹

As indicated in figure 6, a DSP satellite rotates to provide the locomotion needed to move its angled telescope in a repeating cone-shaped search pattern across the earth's surface. Since each satellite revolves at a rate of about six turns per minute, approximately ten seconds elapse between successive scans of a specific area. Since the DSP detects all major infrared sources such as jet aircraft using afterburners, gas being flared in oil fields, and missiles being launched, it requires several successive scans of a suspected missile signature to determine if the signature is moving and if the movement fits the profile of a ballistic missile.²⁰ Since a missile cannot be detected while it is below clouds, the DSP system may require more than a minute to report a missile launch and to determine an initial direction of flight.

The DSP also provides IR spectrum data on the missile's plume so that the ground-control team can determine the type of fuel being burned by the missile, which helps U.S. Space Command to classify the missile.²¹

As noted in chapter 1, an ICBM (such as the Russian SS-27) can maneuver during its boost phase, a move likely designed to confuse the DSP system in predicting the missile's intended direction of flight. Considering this countermeasure and the fact that the DSP sometimes falsely reports missile launches and generates imprecise data, it is not desirable to

¹² Captain F. Singcaster, "Captains in Missile Warning Link," 28 February 1996, <http://www.dnd.ca/commelec/vol32/part16.html>. The author was a member of U.S. Space Command's Surveillance and Warning Missile Support Team at the time the article was written; "U.S. Air Force Tries To Save A Satellite Left Stranded," *New York Times*, 12 April 1999.

¹³ U.S. Air Force Space and Missile Systems, "DSP-1 (5 Flights to Date, 1989-1998)," <http://www.laafb.af.mil/SMC/MT/DSP/HISTORY>; Jeffrey T. Richelson, *America's Space Sentinels: DSP Satellites and National Security* (Lawrence, KS: University Press of Kansas, 1999), 237-42 (appendix A); and 45th Space Wing Public Affairs, "Air Force Titan Launch Success," *News Release*, 9 May 2000. DSP satellite number 19 failed to reach its designated orbit in April 1999.

¹⁴ Richelson, 130.

¹⁵ Richard S. Friedman, Lt. Col. David Miller, Doug Richardson, Bill Gunston, David Hobbs, Max Walmer, *Military Satellites*, "Advanced Technology Warfare" (New York: Salamander Books Ltd., 1985), 74.

¹⁶ *Ibid.*; and U.S. Air Force Space and Missile Systems, "DSP Engineering History."

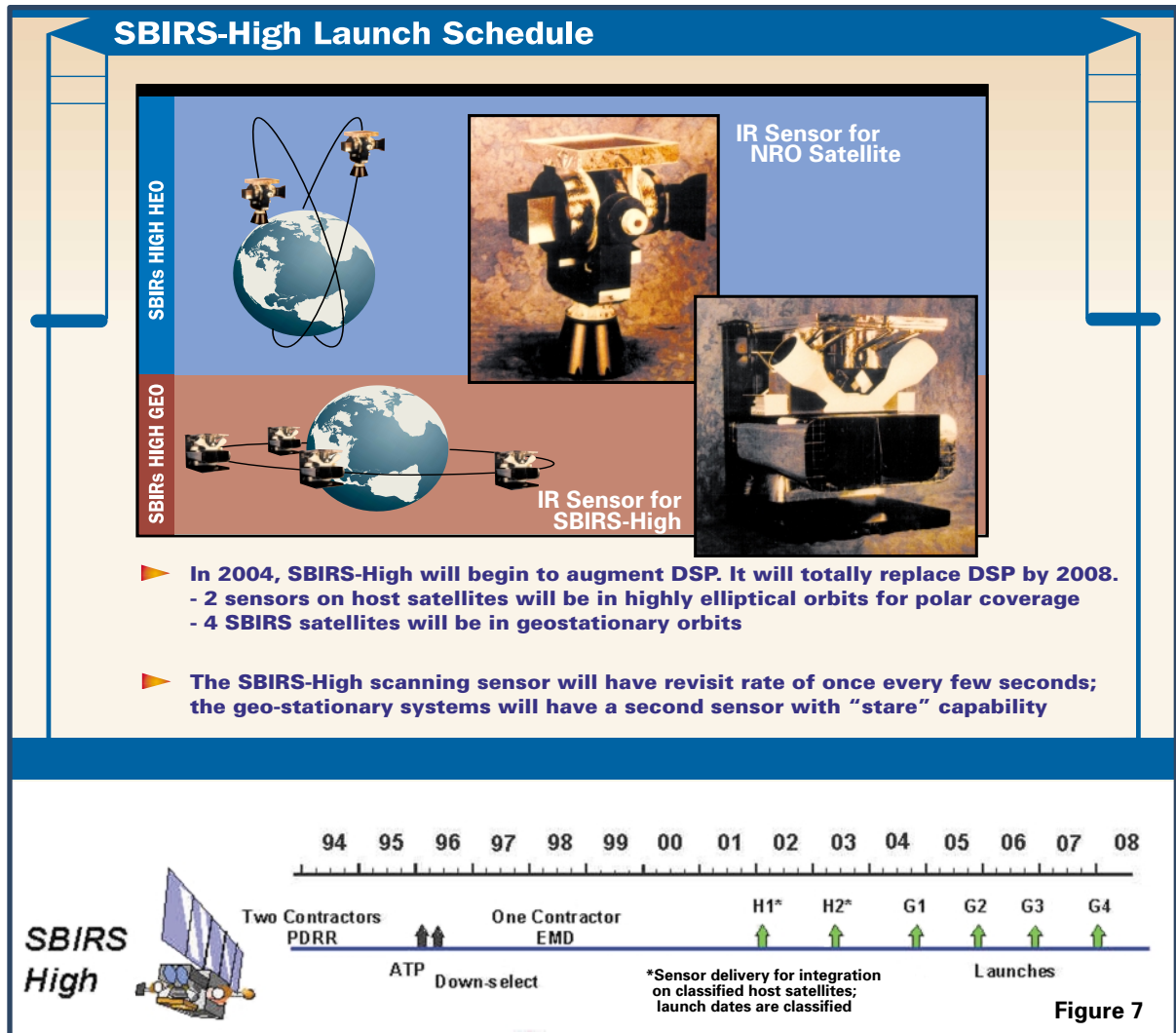
¹⁷ "DSP," *Space Systems Forecast*, Forecast International, 1998.

¹⁸ U.S. Air Force Space and Missile Systems, "DSP Engineering History."

¹⁹ Richelson, 237-242.

²⁰ Forecast International, "DSP."

²¹ Richelson, 237-242.



launch a missile defense interceptor solely on the basis of a DSP report. In a few cases, the battle manager may be forced to do so because of the threat situation, but it is not the preferred course of action (more later).

Space-Based Infrared System-High (SBIRS-High)

A few shortcomings of the DSP system will be corrected in SBIRS-High, its replacement system. Even though the technical details of the SBIRS-High program are not yet in the public domain, it is possible to determine its general system capabilities by performing a point-by-point comparison of open-source material on what it will

correct or provide that is not now available from the DSP program.

Point one. The DSP constellation is deployed entirely at locations over the equator. From the equator, infrared events occurring above 82 degrees north or south latitude cannot be detected with much reliability.²² Since ballistic missile submarines often launch missiles from the northern polar region, this region requires monitoring.

The SBIRS-High program improves the detection reliability with two separate program elements (see figure 7). The first allows two SBIRS-High scanning sensor suites to be mounted onto two classified host satellites scheduled to be launched into highly

²² For a detailed discussion of the subject, see George Lindsey, "The Information Requirements For Aerospace Defence: The Limits Imposed By Geometry and Technology," *Bairrigg Memorandum 27*, Centre for Defence and International Security Studies, Lancaster University, 1997, 13-15.

elliptical orbits (HEO) over the North Pole. (The exact HEO launch dates are classified information, but the launches will begin in 2002 or 2003.) The HEO orbit (an egg-shaped orbit) that the HEO satellites will follow produces a recurring orbital pattern that requires about twelve hours to complete, with the vast majority of that time spent over the North Pole. The satellites will be timed so that at least one of them can always “see” the Arctic region, thus correcting a key shortcoming in the current early-warning system. (Note that the air force announced a two-year delay of the SBIRS-High program in 1999. That delay does not affect the HEO-related scanning sensor system, but only the replacement satellite system in the geo-stationary orbits now covered by the DSP program.)

Point two. The DSP system revisits each area in its search pattern once every ten seconds. This slow revisit rate makes it difficult to detect and track fast-burning theater ballistic missiles, which can have booster burn times of under one minute. The SBIRS-High program will operate at a faster revisit rate and has a stare capability that will allow it to determine a missile’s trajectory at burnout.

Four dedicated SBIRS-High satellites will gradually replace DSP satellites in the geo-stationary positions above the equator, beginning around 2004. Each satellite will be equipped with a scanning sensor with a revisit rate of just a few seconds or less. In addition, each of the geo-stationary SBIRS-High satellites will be equipped with a separate “staring” sensor, allowing the system to monitor selected theater-size regions continuously for missile launches or to track missile flights once the scanning sensor has detected them (an internal pass-off of the mission from the scanning sensor to the staring sensor).

The staring IR sensor will provide a much more accurate projection of an ICBM’s trajectory at burnout than is now available. Because much of a missile’s acceleration occurs during the last few seconds of flight the DSP, with a revisit rate of once every ten seconds, cannot calculate how fast a missile is traveling at burnout, thus limiting its ability to determine the missile’s intended target area and probable trajectory. Since SBIRS-High can stare at

the missile’s boost phase using two satellites, it can determine not only the azimuth of the trajectory, but also the velocity and altitude of the missile when it was injected into its ballistic trajectory. Thus, SBIRS-High will provide much more accurate data for launching an NMD interceptor toward an intermediate interception point than the DSP system now generates.

Point three. Even using stereoscopic observation, the DSP’s ground resolution is only 3 kilometers. Although the exact accuracy of SBIRS-High has not been revealed, public statements indicate that it is less than 1 kilometer. This increase in accuracy decreases the margin of error in projecting a missile’s trajectory. However, like the DSP, SBIRS-High will not be able to track the missile’s actual location after burnout occurs.

Point four. The DSP’s multicolor IR sensing capabilities are clearly limited. As shown in the discussion of IR technology, a robust multicolored sensing capability allows objects to be “fingerprinted” with much more accuracy. The new SBIRS-High satellites are expected to have state-of-the-art multicolored IR technology incorporated into their two sensors. Obviously, this will permit better classification of observed missile launches since more complete IR spectrum readings will be obtained.

Point five. The SBIRS-High complex will be much more automated than the DSP system and more economical to operate. Presumably, it will also analyze sensor information faster and provide more data more quickly than does the DSP system.

The Exoatmospheric Kill Vehicle (EKV)

The first-generation EKV will also depend entirely on a passive IR sensor system for target discrimination. Since the EKV is the heart of the NMD system, it is the key component in determining system effectiveness.

The EKV includes sensors for seeing the target array, a navigation system for plotting the vehicle’s course, software for controlling the flight of the booster, computer processors and advanced

software algorithms for discriminating the target array and plotting the intercept course, thrusters and fuel for maneuvering the EKV, and the telemetry equipment for communicating with ground stations and providing feedback on the EKV's status.

Before December 1998, two separate EKV designs – one from Boeing and the other from

Since the first-generation EKV incorporates only a passive visual/IR sensor system, it views the target array in two dimensions; it has no onboard capability to determine the range to target. Consequently, the target array appears as points of light of varying intensity and frequencies projected onto a flat surface. Although the EKV's sensor system will be discussed in more detail

IFT-1A Target Scene

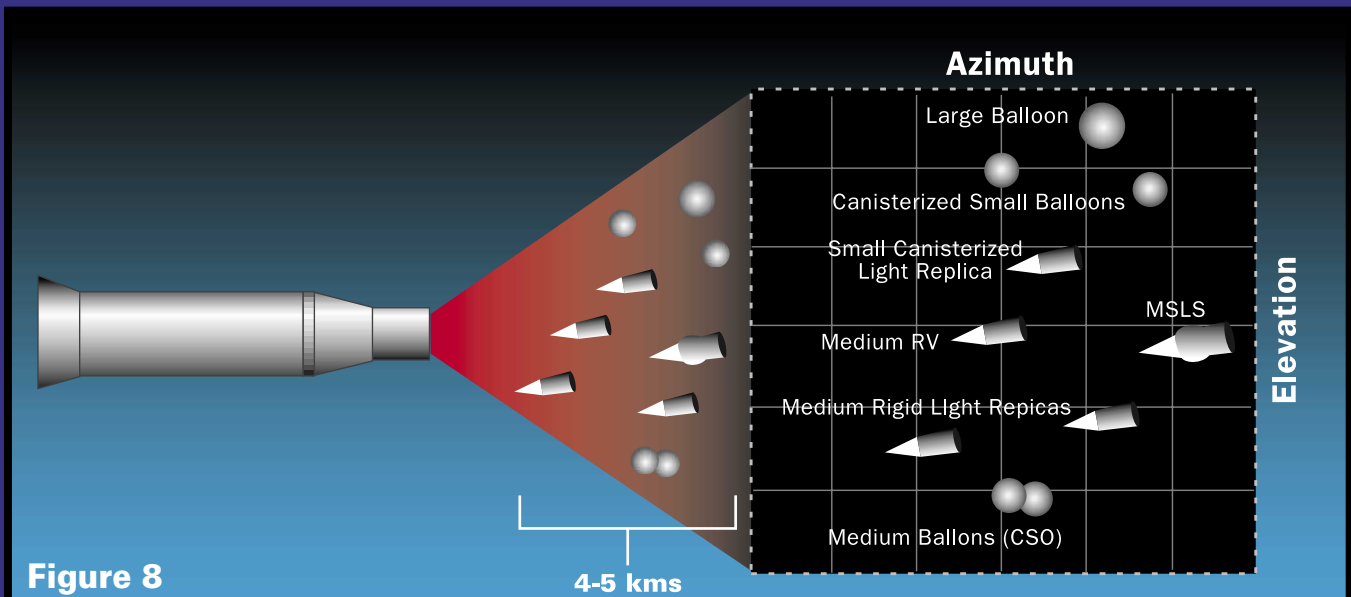


Figure 8

Raytheon – were competing for the final contract award. Both vehicles performed fly-bys of target arrays composed of nine objects (see figure 8). The sun, earth, and a star were also imaged to test the sensors' reaction. The two EKVs transmitted the images captured by their onboard sensors to ground stations for analysis. The results were surprising in that the images produced by both sensor systems were clear; there was no doubt about which object in each of the arrays was the reentry vehicle. Despite the success of both EKVs, Raytheon's design was selected as the lead system for flight testing.²³ Specific system characteristics and capabilities are shown in figure 9. (The Boeing EKV, which had been retained as a backup system until May 2000, is described in appendix C.)

in chapter 4, it should be understood that if the target is sunlit, the EKV will first scan for the target array using its supplemental visible-light sensor system (a charged coupled device – the same technology as that used in camcorders). The two IR sensors will scan for targets located in dark areas and perform the target discrimination function on all targets by detecting medium-wave and long-wave IR emissions from the target array objects using separate medium and long range focal plane arrays, each consisting of 65,536 pixels. These pixels will be bombarded by many IR inputs that must be filtered to determine which signals are target array objects (see figure 10). The only way the initial EKV will be able to determine the distance to its target is if it receives radar-tracking data from ground control.

²³ Daniel G. Dupont and Michael C. Sirak, "Raytheon Selected for EKV Work as Probe Gets Under Way," *Inside Missile Defense*, 9 December 1998, 1-3.

RAYTHEON (HUGHES) EKV

The Raytheon EKV design integrates 8-9 modularized subsystems into the overall system. With the exception of the possible addition of a laser radar, which might require system reengineering, the Raytheon EKV architecture is designed to allow each module to be upgraded or easily replaced as new technology evolves. Navigation is provided by an inertial navigation system which is updated exoatmospherically by star sightings (stellar navigation). The entire unit weighs about 121 pounds.

The Raytheon sensor system differs significantly from the Boeing design. In the Raytheon EKV, the incoming photons are split among three separate sensors, each measuring a specific part of the spectrum using three separate 256X256 pixel focal plane arrays that respectively measure visible light, medium-long IR, and long-wave IR. The key technical aspects are:

- As light comes through the acquisition telescope, it encounters the first beam splitter which reflects part of the photons onto an uncooled silicon focal plane array (charge-coupled device) that measures visible light.
- The remaining photons continue on to a second beam splitter that diverts some energy to a mercury-cadmium-telluride (HgCdTe) focal plane that measures medium-wave IR signals. The remaining photons are directed onto a third HgCdTe focal plane that measures long-wave IR. This sensor is cryogenically cooled to about 40° K. The output from each independent sensor is routed to a common processor.
- The complete sensor suite is tungsten-shielded against radiation and is able to protect itself from EMP effects by cutting power if a pulse is detected entering the telescope; the system can reboot within one-half second after emergency shutdown.

Mercury-cadmium-telluride IR sensors have some notably special characteristics:

- HgCdTe can detect IR wavelengths up to about 12 microns (LWIR). Although it provides high-efficiency detection when cooled to 35-40° K, HgCdTe is able to function at warmer temperatures (with gradually increasing noise levels as temperatures rise).
- HgCdTe is extremely difficult to manufacture. Recent technological advancements now allow focal planes to be built with only 1-2 percent dead cells and 10 percent or less variation between cells (a real advancement for this temperamental material). Improvements in digital computing also allow for variations in cell sensitivity to be electronically averaged.
- HgCdTe focal planes are susceptible to radiation and EMP effects and must be externally shielded.

RAYTHEON (HUGHES) EKV

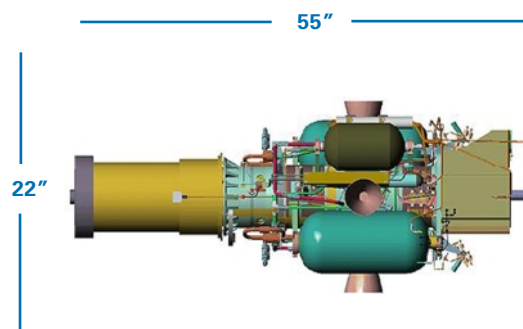


Figure 9

Sources: Aviation Week & Space Technology, March 13, 1997, and Raytheon EKV technologists

As the EKV gets closer to the target array, an increasing number of pixels will activate. Then when it enters its final-approach phase, the target array will “bloom” and quickly activate a great many pixels on the focal plane as the image of the target array fills the sensor’s telescope. (Visually, the image does indeed appear to bloom.) The EKV must then be able to divert laterally and vertically to align its flight path to make the intercept. The kill vehicle’s overall divert capability (a combination of the distance from which it can identify the actual target, and how fast and how far it can move or divert from its forward ballistic trajectory to that needed to strike its aim point) is a critical

element in determining its potential effectiveness as a kill vehicle. (Note that this is also one of the keys in evaluating alternative NMD proposals.)

The EKV’s divert process

A kill vehicle maneuvers on three axes: forward, vertically, and horizontally. The booster’s burnout velocity provides almost all of the forward momentum; in order to maneuver on the vertical and horizontal axes the kill vehicle must use its onboard thrusters. The speed with which these vertical and horizontal movements can be made is called the divert velocity (delta V). The

divert capability is a critical factor in assessing an interceptor's hit-to-kill potential.

Discussions with technical personnel indicate that the divert capability for first-generation, liquid-fueled kill vehicles is well under 1 kilometer once the kill vehicle moves into the end game. By using proportional navigation (making small corrections to the kill vehicle's course while it is well away from its target), the kill vehicle can get close to the target array without much difficulty. However, it is not until the kill vehicle begins the end game that it is able to identify its actual target for intercept.

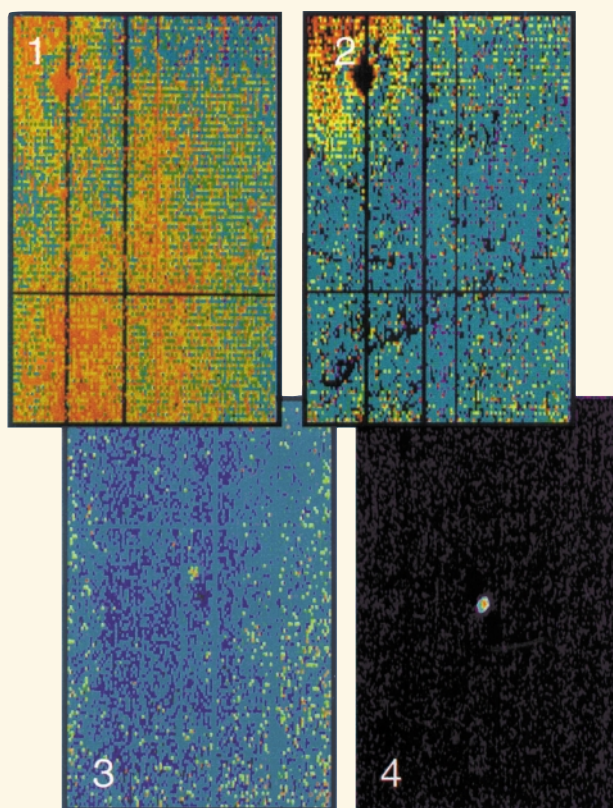
Unlike endoatmospheric intercept systems (systems that operate within the earth's atmosphere), exoatmospheric kill vehicles cannot make the sharp turning maneuvers that characterize their aerodynamic cousins. Hence, maneuvers in space are relatively gentle turning movements in comparison to those that occur within the atmosphere. As shown in figure 11, the determinants of a kill vehicle's exoatmospheric divert capabilities are:

- **The distance from which the sensor's optics and focal plane can identify the reentry vehicle.** The efficiency of the sensor determines the amount of time that will be available for the kill vehicle to maneuver. Obviously, the rapid closing velocities that characterize an engagement against an ICBM will limit maneuver time but, regardless of the velocity, the greater the distance from which the kill vehicle can identify its actual target, the larger its divert envelope will be, since it has more time to make a turning maneuver. Since the objects to be identified are cold bodies emitting only faint levels of infrared radiance, the key to long-range detection is cryogenic cooling²⁴ of the kill vehicle's IR sensors. The IR sensors and related hardware must be much colder than the target array if the sensor is to detect faint IR emissions from long distances. Similarly, if the RV

is cooled as part of a defense penetration technique, the EKV's sensor will not be able to detect that target until it is much closer than would otherwise be the case, thus limiting the size of its divert envelope.

- **The amount of fuel on board the EKV that can sustain a thruster burn over time.** If the kill vehicle only has enough fuel to operate its thrusters for twenty or twenty-five seconds of maneuver, it will have a very limited divert capability. The quantity of fuel carried is part of a trade-off calculation: extra fuel adds mass to the payload, which may slow divert velocity; but less fuel limits the time the thrusters can be operated to make an extended turning maneuver.

Required Processing of IR Sensings



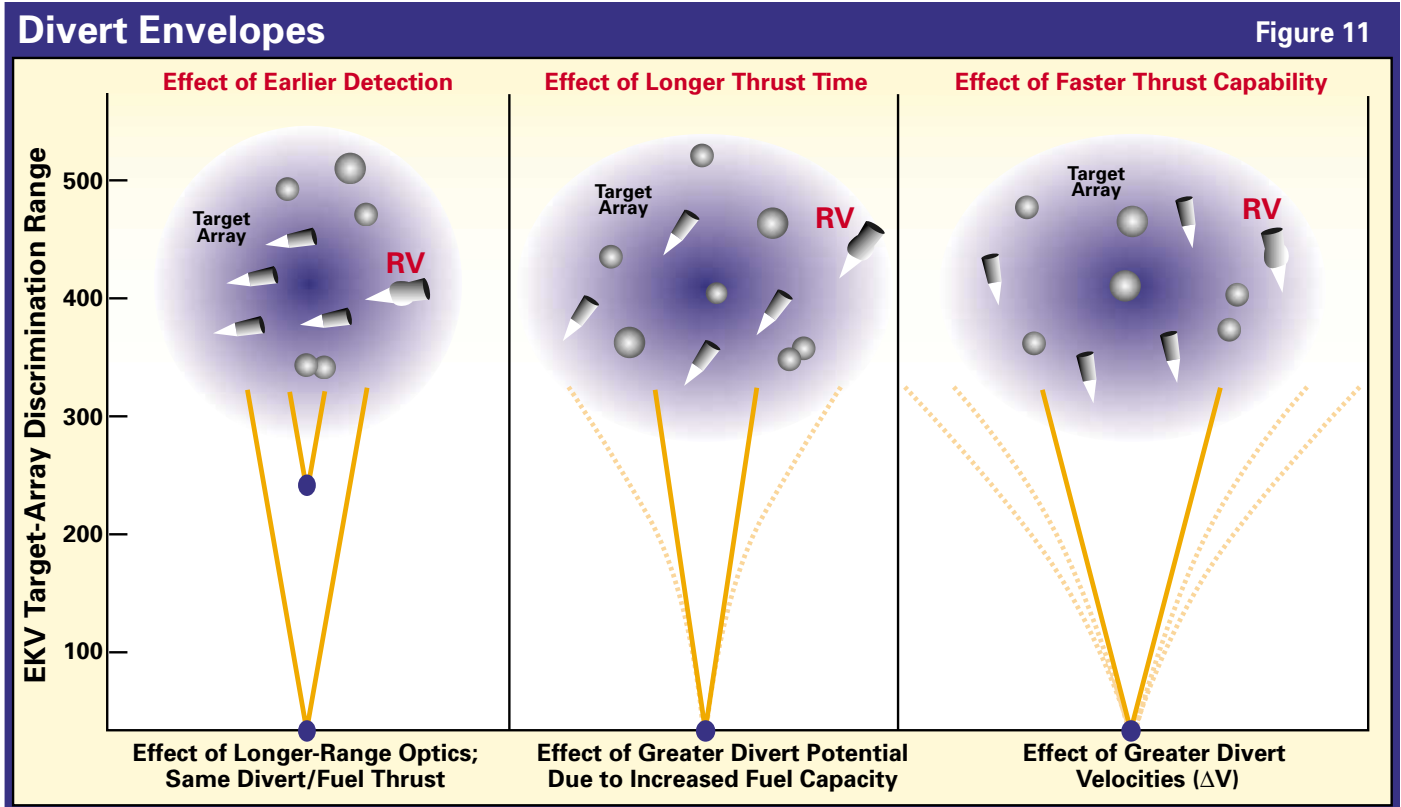
Computer algorithms are used to eliminate noise and background from infrared focal plane data as shown here:

1. Raw focal plane data
2. Infrared spikes subtracted
3. Background subtracted
4. Target acquisition

Figure 10

²⁴ In the case of the Raytheon EKV, cryogenic cooling reduces the temperature of its focal planes to 40°K, (–233°C).

Figure 11



- **The velocity or speed that can be generated to perform the divert maneuver** (that is, the efficiency of the divert mechanism in comparison to the mass to be maneuvered). The greater the divert velocity, the sharper the turn.

Controlling the EKV

In order for the intercept to be a success, the string of software commands (the algorithms) must be coded correctly so that the EKV successfully interprets information inputs and steers itself onto a collision course with its target. In addition, the onboard processors must be capable of handling the enormous flow of information that must be processed very rapidly for a successful intercept.

Both foes and supporters of the NMD program have overstated the issue of EKV control. It is common to hear the intercept problem described as attempting to hit a bullet with a bullet. In this case, however, one of the bullets is equipped with an infrared homing device. While it has also become common to classify all failures of hit-to-

kill intercept attempts as failures of the hit-to-kill concept, many test failures so attributed are in fact due to other technical problems or human errors that had nothing to do with hit-to-kill intercept capabilities.

While it is true that in human terms, the hit-to-kill intercepts occur very rapidly, with the final maneuvers occurring in just seconds, in computer terms this is not so fast. Computers operate in nanoseconds (billionths of a second). While many human physical reactions require a full second or two to accomplish, a very fast computer may have gone through millions of decision gates within the same timeframe. Consequently, a computer-guided intercept is measured on a time scale much different from what humans experience. This does not mean that the ultimate processing challenge is not significant. It is significant, but more from the aspect of the amount of data that will be sent through the EKV's processors as it assesses all the various inputs and makes decisions regarding which object to attack, rather than the more simple process of steering the EKV along

the intercept course calculated based on the target discrimination decision-making process.

Obviously, the more complex the target array, the greater the computational requirements. Currently, the EKV's contract specification requires it to hit the target 90 percent of the time.²⁵ Presumably, that percentage is measured against a capability ascribed to rogue states using first- or second-generation missile systems²⁶ – in other words, against target arrays of limited complexity. As the EKV is upgraded in the future to handle the complex target arrays required under the next generation, C2 architecture, processing speed will become a major issue of concern.

The first-generation EKV will not have X-band radar (discussed later in this chapter) or SBIRS-Low (see below) data inputs to contend with since those systems will not yet be available or used for target array discrimination by 2005. However, by the time the C2 upgrade is fielded around 2010, the EKV's onboard processing capability will have to be greatly enhanced. At that time, all comparisons and integration of targeting information from the radar systems, SBIRS-Low, and the EKV's onboard sensors will be accomplished by processing systems physically sited on the EKV. This function will require very fast computers operated by advanced software that incorporates a high degree of artificial intelligence. The development of this computing capability is a critical task on the road toward a full NMD capability.

Space-Based Infrared System (SBIRS)-Low

Although the SBIRS-Low program will not be part of the initial NMD deployment, it is a key asset for early target tracking,²⁷ and it will be a crucial element for the upgraded NMD system tentatively planned for implementation in 2010. It is being discussed here because it will use the same type of infrared focal plane as that on Raytheon's EKV

(discussed above), and also because some policy makers are advocating that this program be accelerated for a possible deployment in 2004.

Background

SBIRS-Low is a program to develop a constellation of 24 to 30 infrared-sensing satellites in low earth orbit (LEO) to identify, track, and discriminate missile launches and target array packages early. Since the ground-based radar systems cannot "see" through the earth to track and characterize a target array on the other side of the globe, a space-based system is needed that provides earlier target characterization and tracking information that will permit a correctly tailored interceptor package to be launched before the targets are detected by radar.

The SBIRS-Low program is challenging in that it pushes the state of technology on several fronts while being developed under the mandate that the final system must be relatively inexpensive to deploy (it must not be a system of billion-dollar satellites). In approaching the technology development task, the air force worked to orbit two satellites to prove the technical concepts. Once the technologies were proven, it planned to orbit the entire constellation between 2004 and 2006.

The original technology development effort experienced soaring cost overruns. In addition, questions were raised about the relevance of the demonstration program since the successful deployment of the Iridium constellation made the SBIRS-Low flight test (using just two satellites) difficult to justify. Some of the most significant technological challenges in the SBIRS-Low program involve the autonomous operation of the entire constellation and not just the rather simple problem of communicating between two isolated satellites.

The program was restructured and a new technology development contract was announced on 16 August 1999. The air force's new focus is on

²⁶ Officials associated with the NMD program frequently note that initial NMD efforts are oriented toward rogue-state threats.

²⁷ Most of the information discussed herein regarding the technical capabilities of SBIRS-Low satellites was acquired through conversations with industry representatives manning SBIRS-Low exhibits at the last two annual U.S. Space Foundation symposiums in Colorado Springs, Colorado, April 1998 and April 1999; and Secretary of Defense Cohen's letter of 5 August 1999 to Senator Warner, published in *Inside Missile Defense*, 26 August 1999, 26-28.

²⁵ Bradley Graham, "Missile Shield Still Drawing Friends, Fire," *Washington Post*, 17 January 2000, pp. A1, A12.

reducing the risks of the SBIRS-Low system. The system must be able to detect missile launches autonomously, cue a companion satellite for stereoscopic observation, and relay the information among the SBIRS-Low constellation satellites to a location where it can be downlinked to a ground station. This requirement stresses the current state of technology in such areas as artificial intelligence for the autonomous operation of the system and high data-rate communications to move the high volume of information generated. Under the new program, extensive ground testing is planned to reduce risks in:

- System communications
- Sensor tasking
- Processing capability
- Multi-satellite algorithms
- Operational satellite control and real-time data management

Other areas of concern include long-life space system hardening, long-wave infrared sensitivity, affordable satellite design, improved manufacturing processes, and software.²⁸

Under the new SBIRS-Low program, three satellites will be launched in 2006 and evaluated for one year, three more will be launched in 2007 or 2008 for further evaluation before the remaining elements of the constellation begin to be launched. The first six satellites will be used to test certain system components. Engineers will have the flexibility to retain or change those components on subsequent satellites.²⁹ Once the design has been proven, the remaining systems will begin to be launched; the full constellation of SBIRS-Low satellites will not be in place until 2009 at the earliest.

While the program restructure delayed the date for program implementation, it also resulted in an increase in the resolution of SBIRS-Low's IR sensor. The original design used a mercury-cadmium-telluride focal plane that was only 128 x 128 pixels in size. That design would have produced

a resolution only one-fourth as sharp as that produced by the sensor on Raytheon's EKV. During the rebidding process the focal plane requirement was increased to 256 x 256 pixels (the same as the EKV). This change will provide the system with considerably better resolution than was planned in the original design.

The SBIRS-Low satellites are expected to have a ten-year life span and to be able to track missile systems as well as categorize resident space objects (RSOs). Since the missile-tracking mission requires detection of cold-body objects, the sensor system must be cooled throughout the life of the system.

Target discrimination and the IR sensor system

The sensor system aboard SBIRS-Low includes a short-wave infrared scanning system to detect missile launches below the horizon (with the earth in the background). Once the missile is above the horizon, the tracking function will be passed internally to a second sensor, one that uses a telescope to follow the trajectory while measuring the target array's IR fingerprint over multiple frequencies (colors) in the medium- and long-wave IR spectrum. The system is also expected to have the capability of tracking objects on the visual spectrum, a capability that will be used primarily to examine and classify resident space objects (such as satellites, launch junk, and potential weapon systems).

To overcome the problem of being able to sense objects in only two dimensions, a SBIRS-Low satellite will instruct another SBIRS-Low platform in its vicinity to image an object of interest, thus producing the conditions needed to develop a stereoscopic three-dimensional image of the object(s). Using two or more SBIRS-Low satellites to track an object also allows the system to fix the location of the object with sufficient accuracy for an interceptor launch. Thus, SBIRS-Low is designed to overcome one of the key limitations of ground-based radar, which is the inability to detect and locate missile launches that occur at long ranges

²⁸ Gigi Whitley, "SBIRS-Low Overhaul Stresses Risk Reduction Work, Not On-orbit Flights," *Inside Washington*, 13 February 1999.

²⁹ Warren Ferster, "U.S. Air Force Wants Design Flexibility in SBIRS Low," *Space News*, 26 July 1999.

from the radar locations (discussed later in this chapter) and provide the NMD battle manager with an early description of the target complex so that the needed number of interceptors are launched early.

Unfortunately, the SBIRS-Low system will often be tracking targets at ranges well beyond the capabilities of the EKV. Consequently, the task of being able to discriminate the target array is a major technological challenge. Note that on those occasions when a target array is deployed in the vicinity of one of the SBIRS-Low satellites, the satellite's ability to observe the decoys being inflated and ejected will greatly assist in the discrimination process.

The SBIRS-Low program is generating substantial political debate. Members of Congress and others in the defense policy community have expressed dissatisfaction with the air force's handling of the SBIRS-Low program. Some believe that the air force has shortchanged the SBIRS-Low program to protect its SBIRS-High project. A few experts claim that SBIRS-High will have ques-

tionable utility once the SBIRS-Low constellation is deployed. Others question whether or not the complexities of SBIRS-Low can be overcome and doubt that the system will ever be deployed. This would mean that the United States would only have the SBIRS-High assets for early warning of missile launches. Regardless of the validity of these concerns, it does seem clear that the United States will not have a SBIRS-Low constellation in place until the latter part of the next decade (i.e., 2010).

Active sensors: a look at the radar systems

Radar provides the other half of the NMD sensor equation, and policy makers need to be familiar with the subject. For example, much of the current discussion swirling around the *Aegis*-based NMD option involves a radar issue, as discussed in chapter 5.

Radar transmits an electromagnetic signal, receives faint echoed returns, and interprets the returns to develop a composite image of an object(s). Although any part of the electromagnetic spectrum can be used for radar, most radars are microwave systems, which means that they produce electromagnetic waves between 1 centimeter and 1 meter long. In general, the longer the wavelength the more easily it propagates, or travels, over long distances, but the shorter the wavelength the more information can be gained about an object of interest. Unfortunately, short wavelengths do not propagate well and they are diminished by adverse weather. Since short-wavelength radar systems are necessary in missile defense because they are able to discriminate complex target arrays, these systems must be fielded as systems that are able to propagate the signals over a considerable distance.

A radar capability is required for advanced target array discrimination. As stated earlier, it is possible to alter the infrared signature of offensive warhead packages as a way of countering missile defense infrared sensors. While the initial NMD system will be highly dependent on infrared sensing, advanced radar systems will later be added to the initial NMD capability to pro-

Coverage of Cobra Dane Radar

Figure 12



Source: Jeffrey Richelson, *The U.S. Intelligence Community*, 1999

vide an alternative, and complementary, means of discriminating the target array.

The current early-warning radar system

The United States' early warning radar network comprises five UHF radars that operate at relatively low frequencies of 400 to 430 megahertz (MHz), meaning that they produce relatively long wavelengths. Although these five radars will have nearly identical phased-array³⁰ capabilities by 2001, the three northern systems (located at Fylingdales Moor, Yorkshire; Thule, Greenland; and Clear, Alaska) are called Ballistic Missile Early Warning System (BMEWS) radars. The other two radars, located at Cape Cod, Massachusetts, and Beale Air Force Base in Northern California, are called PAVE PAWS (phased-array early warning) radars. The BMEWS systems were situated and oriented for the purpose of detecting Soviet ICBM launches. The PAVE PAWS radars were situated and oriented to detect submarine-launched missile attacks.

A sixth radar, Cobra Dane, was built on the Aleutian Island of Shemya to monitor the Soviet missile test-range impact area on the Kamchatka peninsula. Cobra Dane operates at about 1.3 gigahertz (GHz), an L-band radar (a shorter-wavelength system). Unfortunately, the northern orientation of this single-faced, phased-array radar leaves it poorly positioned to track potential North Korean or Chinese missile launches that might be targeted against parts of the United States, particularly Hawaii.³¹ (See figure 12.)

All of the above phased-array systems are stationary radars in concrete structures. All but one of the five early-warning radars have two faces and search a 240-degree arc (an ABM treaty limitation). The exception is the BMEWS radar at Fylingdales in the United Kingdom, which is a three-faced,

360-degree system. Each radar face is able to search a 120-degree-wide sector (see figure 13). However, the highest resolution is achieved at or near the face's boresight (the angle perpendicular to the face).

Although each radar face searches a sector extending 60 degrees to each side of its boresight, the resolution achieved declines toward the edge of the search field (similar to a human eye's peripheral vision). For example, radar search beams propagated at 45-degree angles left or right of the boresight axis achieve only 70 percent of the resolution attained by pulses projected near the boresight's vector.³² In practical terms, this means that radar track files for objects located near the limits of the search field (of each face) take longer to establish than for objects tracked nearer the boresight azimuth. For this reason, radars are oriented so that their boresights point in the direction of the greatest assessed threat.

The earth's curvature also creates natural limits on a ground- or sea-based radar's detection capability, especially in the case of long-range, early-warning radar systems. Although the BMEWS/PAVE PAWS radars are capable of detecting objects the size of a small car at a range of about 5600 kilometers (useful for radars' secondary mission of space surveillance), that range capability is much less meaningful in terms of missile detection and tracking.

Since most ICBMs are launched on trajectories whose highest point (apogee) is at an altitude lower than 1400 kilometers, radar range capabilities beyond 4000 kilometers have limited use for the early-warning mission. For example, at a range of 4000 kilometers, the bottom of the radar's search beam is about 1360 kilometers above the earth's surface,³³ meaning that it would detect a launched ICBM only near the apogee of the ICBM's trajectory (see figure 14). *The earth's curvature*

³⁰ A phased-array radar has a search beam that is electronically steered rather than mechanically directed by a rotating dish.

³¹ Jeffrey T. Richelson, *The U.S. Intelligence Community*, 4th ed. (Boulder, Colorado: Westview Press, 1999), 224-225.

³² Background conversation with a Raytheon Corporation executive, April 1999.

³³ According to U.S. Air Force Space Command (<http://www.spacecom.af.mil/hqafspc/library/facts/pavepaws.htm>), the faces of the early-warning radar systems are tilted back 20 degrees: they search on the vertical axis between 3 degrees and 85 degrees. The area below 3 degrees is not searched since the radar would pick up too many extraneous echoes from ground clutter and create a microwave radiation hazard to people and animals. Using a standard math formula for curvature calculations plus the correction for the 3-degree beam angle, the deadspace was computed for various radar ranges.

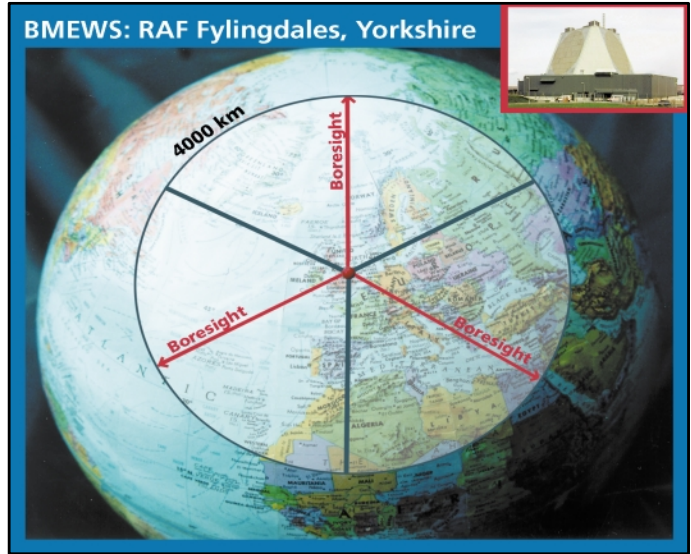
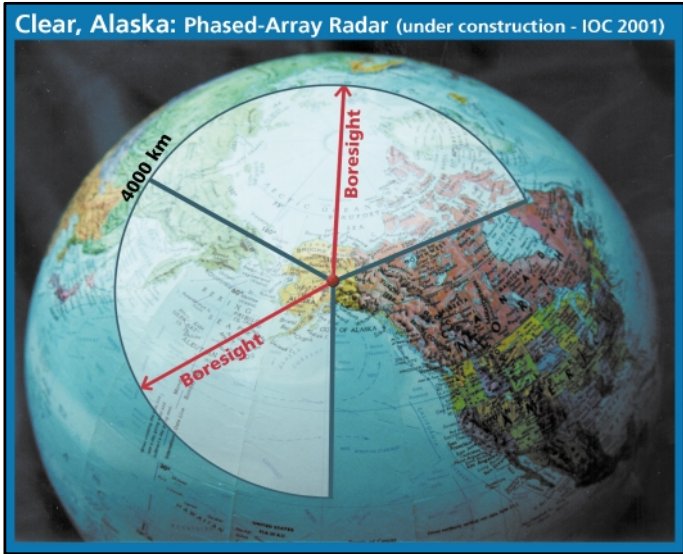


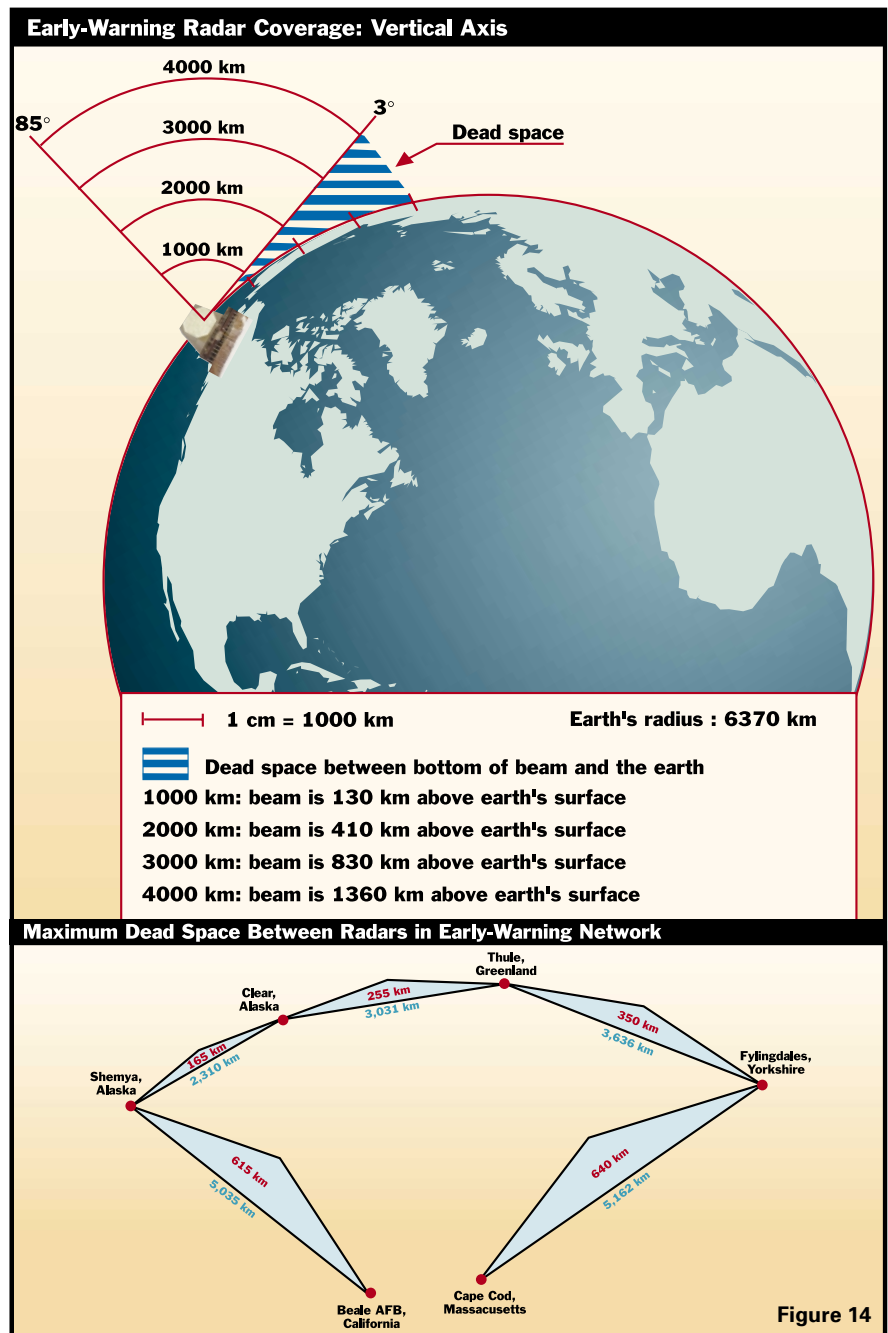
Figure 13

makes it highly unlikely that the radar will detect any portion of an ICBM's trajectory at a distance beyond 4000 kilometers.

There is also a correlation between a radar's effective range and timely cueing. The cueing requirement is especially critical for high-frequency radar systems that have difficulty propagating signals over long distances. When a radar is operating in a standard search mode, it spreads its available power over a broad arc, which limits range and resolution. To increase its effective range, more power must be applied. For non-solid-state radar systems (such as most older dish-type radars), power levels could be surged to handle target detection demands. However, the amount of additional power required is significant, since increases in radar range are proportional to the fourth root of the transmitted power.³⁴ For instance, to double a radar's range requires a 16-fold power increase ($2^4=16$).

In the case of the new solid-state radars, power surges of this magnitude would burn out the microcircuits. Thus, to double the search range requires narrowing the search beam by diverting 16 individual pulses from other search axes and integrating them into a focused beam for transmission in the direction indicated by the cueing system. Likewise, when radar contact is made with a potential target array, more power must be focused on the detected objects to increase resolution.

Given that the power required to increase range is based on the fourth root, decreases in range produce rapid improvements in radar resolution. This concept is analogous to the case of an automobile headlight. A headlight shines a cone-shaped beam, which at its range limits has a sharp decline in illumination intensity. To increase the headlight's range would require either narrowing the light's beam or increasing



power levels. The same principles hold true for radar systems. *Consequently, the ability to cue the radar accurately and quickly is a key requirement for an effective national missile defense, since long-range target detection and track-file generation will often depend upon the initiation of special radar activities, especially for the initial C1 NMD capability.*

³⁴ Merrill I. Skolnik, *RADAR Handbook*, 2nd ed. (New York: McGraw-Hill, 1990), 1.3.

BMDO's current plan is to upgrade the BMEWS and PAVE PAWS radars to increase their processing capability so as to be able to discriminate between a target array and the missile bodies and to report this information in a timely manner. This upgrade will also permit these radars to determine the number of target arrays being deployed from a single missile. However, the UHF early-warning radars will not be able to "see" the individual objects within each array. Target arrays can only be discriminated by broad-bandwidth, short-wavelength radars, such as an X-band radar, capable of "looking" inside the target array and dealing with multiple smooth-body complexes. For example, the X-Band radar being developed for the NMD mission will be capable of distinguishing a golf ball over Seattle if sited at Washington, D.C.³⁵

The X-band radar system

To handle missile-defense target-array discrimination requirements, the army has developed a solid-state, phased-array, X-band radar system, versions of which will be used by both the THAAD and the NMD systems as well as deployed on selected *Aegis* cruisers.

In addition to the X-band radar, three other radar systems have been considered for use in the NMD mission. These include the early-warning UHF radars discussed above, the L-band radar at Shemya (*Cobra Dane*), and the navy's *Aegis* radar system (the SPY-1). Figure 15 shows the frequencies and the wavelengths associated with each of these systems. As discussed earlier, the *Cobra Dane* radar operates in a wide bandwidth, but since its face is oriented too far to the north for it to monitor missiles launched at Hawaii it has been eliminated from further consideration. Both the UHF early-warning radars and the navy's SPY-1 radar are narrow-band systems, which means that their capacity for extracting information from a complex target array is extremely limited; they can track an array but they cannot identify the objects within it.

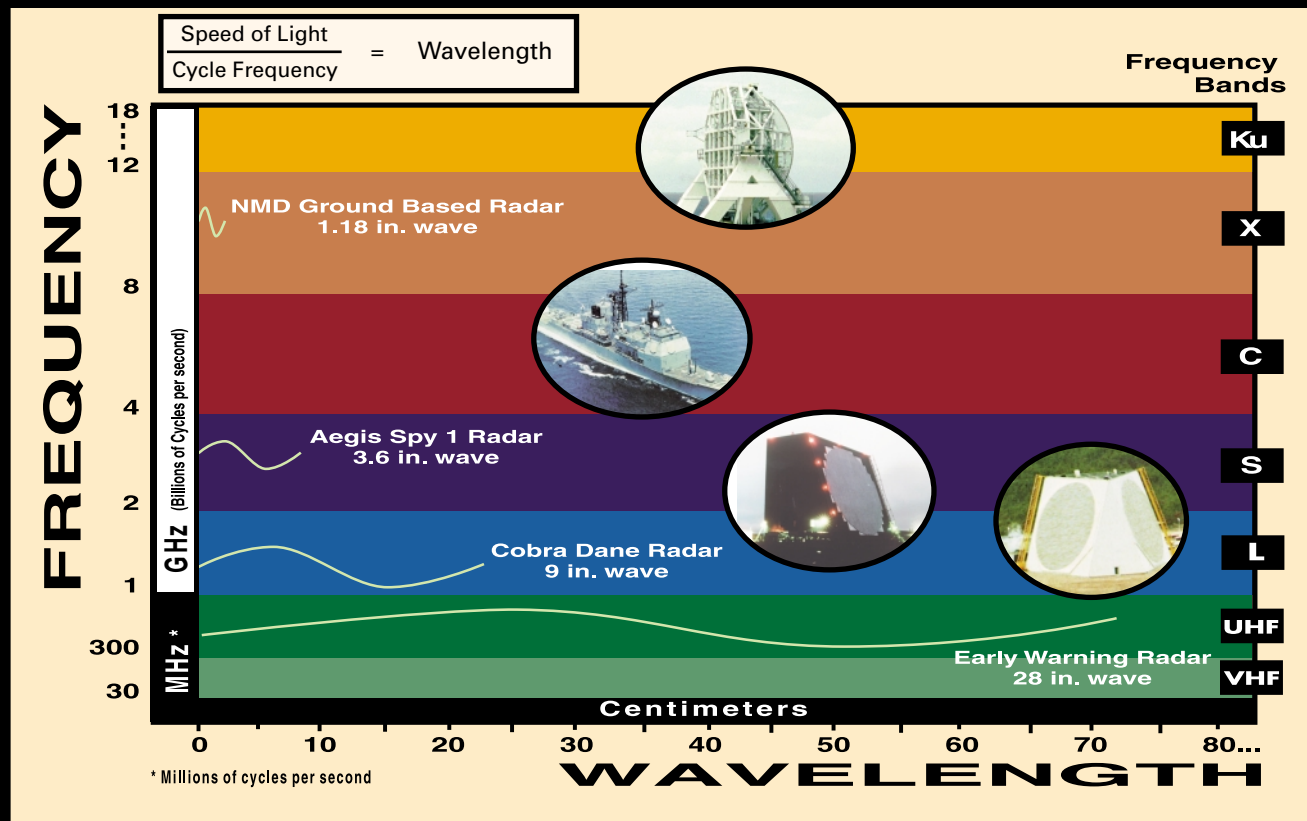
The X-band radar employs highly complex software to encode tens of thousands of individual frequencies (within the 10-GHz range) that are compressed and transmitted in pulsed patterns. Each of these frequency segments carries distinct bits of pertinent information that subsequently are decoded from reflected echoes. This capability allows closely spaced objects or parts of objects to be identified individually by the radar. An X-band radar, for example, has the capability of determining a reentry vehicle's diameter (all along the object's length), length, spin rate, velocity, mass, position of other accompanying objects, *and the respective nose wobble patterns* exhibited by the reentry vehicle and its accompanying decoy systems (a key discriminating factor for determining which object is the reentry vehicle, since reentry vehicles have less nose wobble than do light-weight decoys). It may also be able to determine the material of an object and its density.³⁶ Figure 16 shows the process that the X-band system uses to discriminate target arrays.

The picture of the piano keyboard in figure 16 illustrates the bandwidth issue. In the case of the early-warning UHF and *Aegis* SPY-1 radars, their bandwidth (the keyboard length in the figure) is but a fraction of that used by the X-band system. A narrow-band radar can be thought of as a child's piano (a foot-long keyboard). The narrow bandwidth (number of frequencies, or of piano keys) limits the capability for narrow-band radars to encode complex pulses, just as it is impossible to play a complex piece of classical music on a child's piano. Consequently, within the radar family only the X-band radar, with its greater number of frequencies, currently has the potential for discriminating complex ICBM target arrays. As will be discussed later, a laser radar should be available in 2003 for possible integration into the NMD platforms that operate in space. If integration of a laser radar proves necessary, that radar will provide additional onboard discrimination between the reentry vehicle and accompanying sophisticated decoys.

³⁵ BMDO has been using the PAVE PAWS radar at Beale AFB to test upgrades to the early-warning radar network. The golf ball example was used in testimony by Lt. General Ronald Kadish, National Missile Defense, R&D Subcommittee, House Armed Services Committee, 22 June 2000.

³⁶ For a more detailed discussion of the advantages of increased radar bandwidth see Donald R. Wehner, "High Resolution Radar," *Artech House Library*, 1987, 3. For new information on the capabilities of the X-band radar see Robert Wall, "More NMD Testing, Decoy Work Urged," *Aviation Week & Space Technology*, 26 June 2000, p. 30.

A LOOK AT NMD ASSOCIATED RADARS: A COMPARISON OF THE RADAR WAVELENGTHS



Radar Frequency Selection is Based on "Compromise"

Higher Frequency Radar

Short-wave Advantages

- Provides maximum opportunities to manipulate the wave-form to increase data collected
- Yields the most detailed "picture" of the target array (more accurate measurements)
- Not affected by sunspots and nuclear effects

Short-wave Disadvantages

- More expensive to build capability to propagate over long distances
- Degraded by adverse weather such as rain and snow

Lower Frequency Radar

Long-wave Advantages

- Propagates well through the atmosphere
- Able to search broad sectors and detect target clusters at long range using reasonable power levels

Long-wave Disadvantages

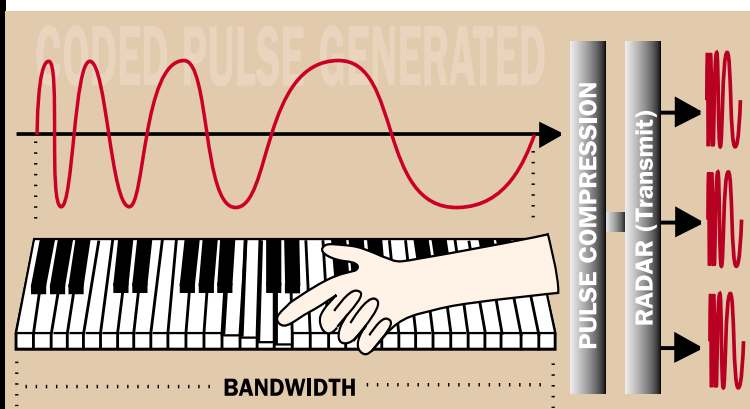
- Unable to discriminate between complex, closely-spaced smooth objects in a target cluster
- Degraded by sunspots and susceptible to nuclear effects

Figure 15

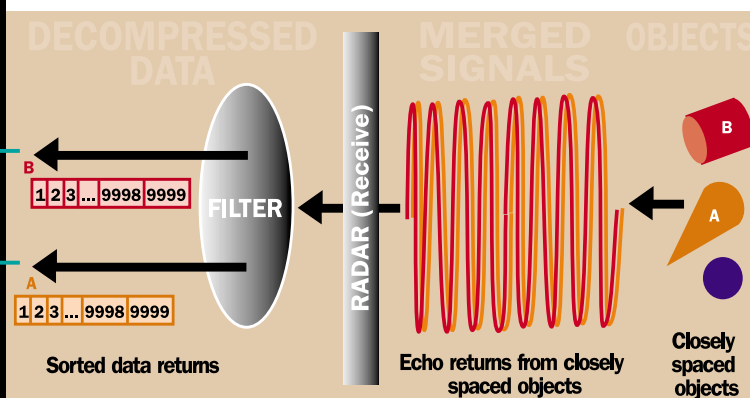
Figure 15

A Look at X-Band Radar

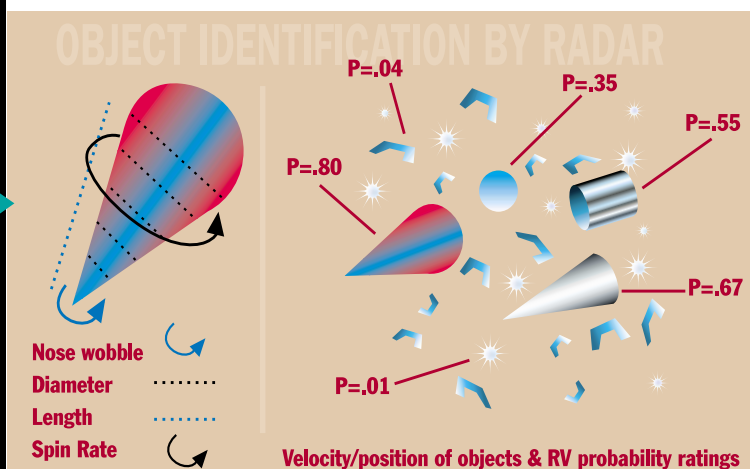
Advanced X-band radars use wideband linear frequency modulation (LFM) pulse compression which allows echoed returns from closely spaced objects to be sorted by the radar.



Separating the coded pulse return:
maximum data, minimal jamming effectiveness.



Correctly identifying an RV—looking for specific characteristics.



Use of X-band, short wavelength radar (in optical terms) is like seeing objects in sharp focus as opposed to the blurry shadows of longer-wavelength frequencies

SYSTEM BASICS:

- Transmitted pulses are composed of progressively higher frequencies (similar to that produced by a pianist rippling up the note scale—the length of the keyboard represents the bandwidth).
- Each grouping of waves is compressed (using various methods) into a short duration pulse.
- The echoes heard by the radar from closely spaced objects or parts of objects are received as merged signals, but the coded waves in the compressed pulse can be separated and its segments individually identified by the radar.
- This technical approach improves range resolution measurements and makes jamming operations more difficult.

WHAT CAN BE DETERMINED BY X-BAND RADAR SYSTEMS:

- Amount of nose wobble motion (is it characteristic of an RV?)
- Diameter (along its length)
- Length
- Spin rate and mass
- Velocity and position of objects

Figure 16

The other non-sensor NMD systems

Two other components will be included in the planned NMD system. The first is the commercial booster that will launch the kill vehicle, and the second is the command-and-communications system.

The booster

After examining several launch vehicle options, including the possibility of rebuilding *Minuteman* missiles for use as NMD launchers, Department of Defense officials made a decision on 15 July 1998 to use commercial booster motors in the NMD launch vehicle.³⁷

The three-stage interceptor selected will consist of a first-stage graphite epoxy motor (GEM) from Alliant Techsystems (see figure 17), and a second and third stage comprising two stacked *Orbus* 1 motors from Pratt and Whitney.³⁸ The first-stage booster is the same rocket engine that is used as a strap-on booster for the *Delta* space-launch vehicle; it has been used over 520 times without failure. The two upper-stage rocket engines, using the *Orbus* 1, represent a new system that has flown seven times, all without failure.³⁹

Reports have circulated that the two *Orbus* 1 engines might be replaced by a single, more powerful, *Orbus* 4 engine in the final configuration of the stack. The ultimate upper-stage configura-

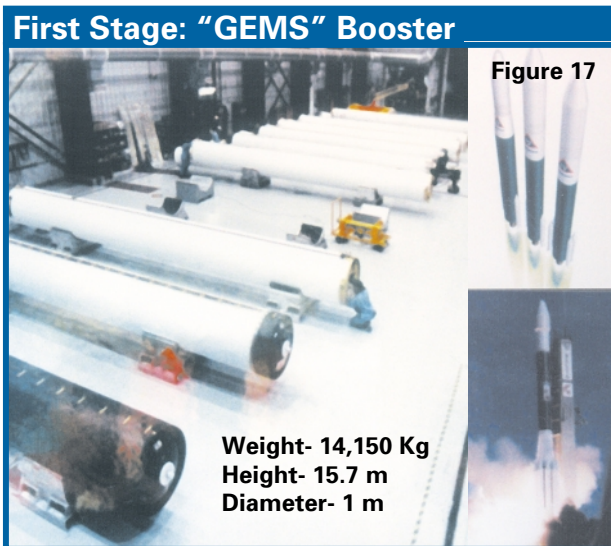
tion will depend on the final weight of the kill vehicle and the fly-out velocity needed to protect all fifty states versus other system considerations.⁴⁰ For example, the faster the booster propels the EKV to its intercept location, the more stress the EKV must be able to withstand during the boost phase and the faster the closing velocity will be as it approaches the target array. A faster approach can limit the time available for target discrimination and divert maneuvers by the EKV.

Note that the booster stack will be operated and commanded by the EKV. Thus, the integration of the EKV's command module with the booster stack and the development of software that the EKV will use to control the booster are development steps that have not yet been completed.

Battle management/command, control, and communications system

This system includes up to five pairs of ground-to-space communication systems to be fielded at the command center and on the periphery of the United States to provide the communication links

between the ground-based elements and the in-flight EKV. These systems are needed to provide updates to the EKV's guidance system regarding the location and composition of its assigned target array as well as to receive feedback from the EKV. The ground-command element will be able to see the target array imaged by the EKV,



³⁷ See "Commercial Boosters Chosen For NMD," *BMD Monitor*, 7 August 1998, 259; and "Boeing's Preferred Missile Defense Concept Rejects Minuteman Boosters," *Inside the Pentagon*, 7 May 1998, 1, 13.

³⁸ Conversation with Dr. John Peller, project manager, NMD-Lead System Integrator Office, 18 December 1998.

³⁹ Peller, testimony before the Subcommittee on Strategic Forces, Senate Armed Services Committee; and Michael C. Sirak, "Boeing's Reserve NMD Kill Vehicle Will Be Maintained At Least Through IFT-4," *Inside Missile Defense*, 19 May 1999, 21.

⁴⁰ Michael C. Sirak, "BMDQ, Boeing Consider Modification of NMD Ground-Based Interceptor," *Inside Missile Defense*, 10 March 1999, 1, 15, 16. Each *Orbus* 1 contains 1000 pounds of fuel; the *Orbus* 4 carries 4000 pounds of propellant.

providing a feedback loop that will assist the battle manager in assessing the complexity of the target array and in determining the likelihood that the reentry vehicle has been destroyed.

Although the ground-based communication assets can be tied to the battle management command center via fiber-optic cable, the ultimate high-data-rate signals between the EKV and the ground stations will be carried by the 20/44 GHz frequency ranges; the very short wavelengths inherent to these high frequencies, unfortunately, are sensitive to atmospheric disturbances. Consequently, the ground-station transmitter/receiver systems must be able to duplicate the transmissions. This redundancy is achieved by deploying the transmitter/receivers in pairs situated 30 to 100 miles apart to ensure that communications can be maintained with the EKV despite adverse local weather conditions.

Technology development timing

As indicated throughout the discussions of various NMD system components, the initial NMD capability obviously will not incorporate the full array of technical capabilities needed for a robust missile defense capability against advanced warhead systems. This means that if a *complex* missile were to be launched at the United States before the incorporation of the planned upgrades to the initial NMD system, the defense would have to expend a larger number of interceptors

“Multiple interceptors per booster or directed-energy weapon systems are needed for a more efficient and cost-effective defense.”

– p. 3.31

to ensure target destruction than would otherwise be the case. For example, rather than launching the normal three to five interceptors at the target array, the defense might have to launch eight to twelve or more kill vehicles to ensure RV destruction. Essentially, for the defense the rule must be that *any object that cannot be discriminated and eliminated from consideration as a potential reentry vehicle must be attacked.*

Missile defense opponents have painted several scenarios to show how an NMD system could be defeated by penetration aids. For example, they note that the RV could be encased in a very large, metal-coated balloon, perhaps 15 or 20 meters in diameter. Since the metallic coating would prevent radar from “seeing” inside the balloon, the RV would be hidden from the interceptors. Of course, in this case, the first interceptor would attack and explode the balloon (possibly changing the trajectory of the RV) and the second interceptor in the train of launched intercept systems would target the exposed RV.

In a scenario where the RV is shrouded and cooled by a cryogenic gas released into the cavity between the RV and the shroud, the infrared radiance level would be depressed to make the RV difficult for IR sensors to detect. This could cause problems for the initial NMD system since the IR sensors would not be able to detect the target until they were close to the RV. This might mean that a larger number of interceptors could be required to ensure that the target has been detected and destroyed (as in the EKV divert challenge discussed earlier).

Once the X-band radar is deployed in its completed form, the radar will be able to detect and discriminate cooled RVs (identifying nose wobble, spin rates, and so on). The radars will provide the EKV with target-array maps showing the RV location within each target array so that the interceptors can chart the trajectories needed to get close enough to the RVs to detect and destroy them.

Another potential challenge is the possibility that the RVs will be encased in a metal-coated balloon that is released with dozens or even hundreds of other balloons of the same size. As noted earlier, the United Kingdom probably used this technique in its *Chevaline* program. To counter this type of pnaid would require one of three actions: 1) The United States could ensure that it has the capability of observing the balloons being inflated during payload deployment; 2) the United states could equip the EKV with a laser radar capable of detecting erratic balloon movements indicating a concealed object; or 3) it could

develop a means for destroying all of the balloons, such as submunition-equipped interceptors or the selected use of very small nuclear warheads to burst the balloons.

The government's solution for this challenge is unknown. However, it seems likely that the United States has opted for one or both of the first two solutions postulated. Although it is not clear what role the black programs might play in inspecting missile payloads as they are deployed, it is conceivable that they might provide some discrimination capabilities, especially in light of the reported capabilities of the NRO's new satellite surveillance systems scheduled to begin deployment in 2005.⁴¹ The second solution likely involves a laser radar. It has been reported that the laser radar will be ready for integration into the NMD program by 2003.⁴² This technology could be added to either the upgraded EKV or the revised SBIRS-Low satellites, or even to both. The laser radar would solve many of the penaid challenges postulated by NMD opponents.

In short, the technology available for incorporation into the NMD system in 2005 should be very capable against target arrays of simple or medium complexity, but it will not be able to identify all of the objects that could be included in a complex array. If faced with a complex array, it will have to use mass (many interceptors) to overcome the technological sophistication of the target complex. When the rest of the planned technology is integrated into the deployed NMD system as it is upgraded, the discrimination capability against complex targets will improve and the number of interceptors needed to ensure target destruction should decrease. Beyond these planned system improvements, a number of other courses of action could be taken, as described below.

Plotting the Path to Future Technology Development

As mentioned earlier, BMDO is currently developing a new type of exoatmospheric sensor technology that should be ready for insertion into the national and theater missile defense systems by 2003. Five areas of concentration, which will increase the lethality of the EKV's, are involved in this technology development program:

"Only about one-third of the priority technology programs needed for future requirements are being funded."

– p. 3.31

- **Advanced laser radar (LADAR).** From a distance of 180 kilometers, LADAR will be able to determine the range to an object with a resolution of 20 centimeters (8 inches).⁴³ Although the LADAR is a "spotlight" system that must be directed to a point of search, it will provide the EKV with accurate ranging information for better control of the intercept. LADAR will also provide information on such things as the movements of penaid balloons, which will help determine if a metal-coated balloon is concealing an RV (since the RV will bump against the side of the balloon and cause the balloon to move differently than the other balloons). Experts hope that a future LADAR generation will be able to provide higher-resolution images of target objects from a distance of at least 250 kilometers (to increase the EKV's divert potential).
- **Advanced focal plane array.** This is aimed at the problem noted in the EKV discussion of the need to be able to handle more data faster to process all of the inputs that will be provided by the full system.

⁴¹ The National Reconnaissance Office (NRO) is planning to begin orbiting a new constellation of satellites in 2005 under a program called Future Imagery Architecture (FIA). The NRO's FIA satellites will provide high resolution optical and radar imaging reconnaissance operations. The new satellites will be highly capable, but much smaller and less expensive than current radar and imagery space systems. Within the FIA design, commercial imagery satellite capabilities will also contribute to the country's overall data collection capabilities. Although it has never been raised, it seems possible that the new NRO satellites could contribute to the NMD target discrimination challenge. See *National Reconnaissance Office Press Release*, "NRO Announces FIA Contract Winner," 3 September 1999; "Boeing Team Wins Future Imagery Architecture Competition," *Defense Briefing*, Lanham & Associates, <http://www.defensebriefing.com.ms-7.htm>, 3 September 1999; Warren Ferster, "DoD Faces Big Bill For Data Handling," *Space News*, 22 November 1999, p. 1; and "Too Late In the Game," *Space News* (editorial), 29 November 1999, p. 14.

⁴² "BMDO Plans FY-03 Delivery of Active-Passive Seeker Technology To Exo-Programs," *Inside Missile Defense*, 10 February 1999, 1, 21.

⁴³ Dr. Charles Infosino, "Technology for Future National Missile Defense," talk given at IFPA symposium *Assessing National Missile Defense: A Roundtable Review*, Reserve Officers Association Building, Washington, D.C., 5 May 1999.

- **Advanced materials and structures.** The program for advanced structures includes the development of new high-strength, light-weight, EKV composite structures and nozzle designs. For example, one thruster nozzle design is about ten times lighter and has four times the strength of current designs.⁴⁴ Lighter weights and stronger thrusters will improve EKV maneuver capabilities (the delta V/divert envelope).
- **Battery development.** An improved power source is needed.
- **Algorithm (software logic formula) development.**⁴⁵ Better software algorithms will also improve the capability of the EKV to interpret and to integrate all of the data it receives.

These improvements are likely to be embedded in the upgraded kill vehicles that will be deployed around 2010 (C2 architecture).⁴⁶

As for future technology development requirements, two technological paths need to be pursued. The first is evolutionary technologies to increase the lethality of the initial NMD architecture (some evolutionary technology was discussed in the foregoing). The second path is the revolutionary technologies needed to provide the United States with the edge required to defeat missile threats beyond 2015.

Other evolutionary technologies

Technologies that are needed to enhance the capabilities of the initial NMD system include:

- **Higher-power, lower-cost radar transmit / receive (T/R) modules for the ground-based radar systems.** As discussed earlier, a key to long-range radar discrimination of a target array is the radar's ability to illuminate the target with high quantities of power. Currently, most solid-state radars are able to convert less than 40 percent of the power available

to the system into radiated electromagnetic waves. The rest of the power generates heat, which increases the level of electronic noise (a system detraction) and increases the size and weight of the cooling infrastructure necessary to maintain radar operations. If more efficient radar materials could be developed, the X-band radar systems would be able to discriminate target arrays at greater ranges. Since this technology is also used in theater missile defense systems, reducing the weight and size of the tactical systems would also make the radars easier to deploy. At the same time, better methods of manufacturing T/R modules must be developed to lower the cost of these expensive components.

- **Integration of radar and infrared sensor data.** Currently, the three-dimensional image developed by radar systems cannot be integrated automatically with the two-dimensional images captured by infrared sensors. A software algorithm needs to be developed for this integration process. Even when the initial algorithm is developed, it is an area of research that will pose a continual requirement for upgrade since the complex tasks involved will need to be done better in the future than the first-generation effort will likely yield (just as Microsoft Windows 3.1 was not adequate for the Internet era).
- **Advanced interceptor technologies** will be needed as countries react to missile defense deployments. For example, an even more sensitive infrared seeker will be needed for more advanced target-array discrimination. The initial laser radar must also be improved to provide higher resolutions at longer ranges. The target discrimination data that will be processed on board the kill vehicle will require much more capable processors than are now available. For example, the challenge of discriminating the hundreds of objects in the sensor's field of view will require object interrogation by the sensor suite at a speed that will create a data processing load that is one thousand times faster than

⁴⁴ "BMDO Plans FY-03 Delivery of Active-Passive Seeker Technology To Exo-Programs."

⁴⁵ Ibid.

⁴⁶ The date has not been announced. However, when asking a BMDO representative if the improvements would be incorporated into the C1 EKV, the author was told no, it is part of the next phase.

the processing rate of the Pentium II.⁴⁷ Clearly, a different technology is needed to handle this extremely complicated processing requirement.

Revolutionary technologies

Following are two areas where revolutionary, rather than evolutionary, technologies are required to move the missile defense program ahead:

- In the long term, the United States needs a **better way of dealing with multiple target objects**, one that is more efficient than launching separate interceptors with single kill vehicles for each undiscriminated object. Multiple interceptors per booster or directed-energy weapon systems are needed for a more efficient and cost-effective defense.
- **New sensor technology** will be required in the future beyond X-band radar, laser radar, and infrared. For example, ultraviolet sensors might need to be incorporated into a future sensor suite to detect targets equipped with stealth technology and technologies that spoof infrared sensors. Ultraviolet sensors would be unaffected by flares or attempts to alter the temperature of the reentry vehicle.⁴⁸ Obviously, the addition of this sensor into a kill vehicle's sensor suite would further exacerbate the onboard processing challenge. At the same time, the possibility that the United States might add an ultraviolet sensor to the EKV creates a risk for penaid engineers who might expend large amounts of scarce resources developing counters to missile defense infrared sensors, just to have the United States add an ultraviolet sensor to its EKV, a sensor impervious to IR spoofing.

"...if the United States is to maintain a capable missile defense program that provides a real deterrent to ballistic missile threats and further missile proliferation, then it must have a sustainable plan of action which will improve its defenses over time."

– p. 3.31

One of the great ironies of the current missile defense program is that funding for technology research has been declining as most available funds have been redirected toward system procurement. Only about one-third of the priority technology programs needed for future requirements are being funded.⁴⁹ From a strategy viewpoint, the signal being sent is that the United States is developing a fig-leaf NMD system, a defense that might be penetrated with a little more effort on the part of the states where WMD are proliferating. Clearly, if the United States is to maintain a capable missile defense program that provides a real deterrent to ballistic missile threats and further missile proliferation, then it must have a sustainable plan of action which will improve its defenses over time.

Chapter 4 examines the military's program for integrating and testing the technologies described in this chapter. Chapter 5 will examine the alternative NMD options that have been proposed, such as the use of *Aegis*, and weigh the technical capabilities that those proposals would yield in comparison to the land-based system now being developed. Chapter 5 also includes a short review of the potential capabilities of a space-based laser system and the roles it could play in providing an effective missile shield.

⁴⁸ Conversations with Dr. Dan McMorow, John Hopkins University Jet Propulsion Lab, 1998-99.

⁴⁹ U.S. Department of Defense Ballistic Missile Defense Organization, "Research and Development Investment," June 1999 (delivered to the House Armed Services Committee, July 1999); and Lieutenant General Ronald Kadish, "Testimony on Ballistic Missile Defense Programs," House Armed Services Committee, Military Research and Development and Military Procurement Subcommittees Hearing, February 16, 2000.

⁴⁷ Dr. Charles Infosino, "Technology for Future National Missile Defense."



The NMD Program

On 20 January 1999, the U.S. secretary of defense announced that the United States Defense Department was allocating additional funds to the U.S. national missile defense (NMD) program to meet the growing potential for rogue states to threaten U.S. territory with ballistic missiles.¹ In that announcement he outlined the administration's new position on NMD:

Our deployment readiness program has had two key criteria that must be satisfied before we could make a decision to deploy a limited National Missile Defense: there must be a threat to warrant the deployment, and our NMD development must have proceeded sufficiently so that we are technologically ready to deploy. What we are saying today is that we now expect the first criterion will soon be met, and technological readiness will be the primary remaining criterion...While our NMD development program is being conducted consistent with the terms of the ABM [Anti-Ballistic Missile] Treaty, our deployment may require modifications to the treaty and the administration is working to determine the nature and scope of these modifications. We have

already begun environmental site surveys for potential basing sites in both Alaska and North Dakota, and we have briefed Russian officials on these activities...A deployment readiness review will be held in June 2000 in order to assess the NMD program's progress and to provide information for a deployment decision. ...Deployment could occur with low risk in 2005...If testing goes well, perhaps sooner.

According to the secretary of defense's statement the critical challenge at this juncture is to assess and test the technology described in chapter 3 and determine whether or not the technology is ready for fielding. Subsequent administration statements added costs and arms control considerations (see chapter 2) to the list. An implied task, included in the readiness of the technology assessment, is to determine if the

¹ U.S. Department of Defense Press Conference with William S. Cohen, secretary of defense, and Lt. Gen. Lester L. Lyles, director, Ballistic Missile Defense Office, room 2E781, the Pentagon, 20 January 1999. A summary of the announcement was released by the Office of the Assistant Secretary Defense (Public Affairs), "Cohen Announces Plan to Augment Missile Defense Programs," news release No. 018-99, 20 January 1999.

system fielded will provide an effective national missile defense against limited ballistic missile threats (see chapter 1).

In anticipation of the NMD program assessments that will occur over the next couple of years, this chapter examines the application of the technologies described in the preceding chapter and projects the overall functioning and potential capabilities of the NMD system of systems. It focuses on the NMD development program and its projected capabilities. Specifically, this chapter describes the development of the current NMD program, explains the testing and deployment programs currently being pursued by the Department of Defense, and examines the projected capabilities of the deployed system--reviewing both its strengths and its limitations.

NMD threat levels: a limited challenge

When the Ballistic Missile Defense Organization (BMDO) first examined the types of attack against which an NMD system should be able to defend, it developed a threat matrix consisting of four system-threat (ST) groupings (since then refined and reorganized). It is instructive to examine the original ST categories for the insights they provide into the types of missile threats the NMD system initially was being structured to defeat:

- **ST-1** – An attack by a third world strategic ballistic missile, or several ballistic missiles, involving up to four rudimentary warheads, but with no jamming or sophisticated decoys

NMD Requirements Assessment



NMD Plan Based on Assessment of Missiles Launched From:

- ▶ 5 Geographical Regions
- ▶ Using 13 Threat Scenarios

Figure 1

- **ST-2** – An attack by a Chinese or third world strategic ballistic missile or several missiles, involving up to four warheads, including a rudimentary ascent shroud to present a cold target in the midcourse phase
- **ST-3** – A threat posed by an accidental launch of four Russian SS-25 ICBMs armed with sophisticated jammers and decoys
- **ST-4** – A threat posed by an accidental or non-sanctioned launch of two Russian SS-18 ICBMs armed with up to 20 RVs and fitted with sophisticated penails and jammers²

During the second half of the 1990s, these four categories were reorganized into three threat levels corresponding to national missile defense architectures named Capability 1 (C1) through Capability 3 (C3). There are indications that while reformulating these categories, BMDO modified the missile threat depiction to correspond with new intelligence estimates (discussed in chapter 1). Moreover, when the request for proposals (RFP) for the NMD lead system integrator (LSI) contract was issued, the potential bidders had to develop plans for a Capability 1 architecture able to defend against thirteen threat scenarios based on missile launches from five different geographical regions, as shown in figure 1.

As reportedly specified in the RFP, the attacks from Russia and China would involve unauthorized launch scenarios, while launches from North Korea, the Persian Gulf, and Libya were characterized as deliberate attack situations by regional actors. As will be shown, of the options specified, a ballistic missile attack from Libya or North Korea would pose the most difficulties for the United States in terms of short reaction time and stress on the early-warning system, while Russia and China pose the most difficulties in terms of warhead sophistication under limited-launch scenarios. Clearly, the sophistication of the potential threats outlined range from the simple to the complex (as described in chapters 1 and 3).

A look at BMDO's historical planning concept: Capability 1 (C1) through Capability 3 (C3)

As has been mentioned in previous chapters, BMDO designed three NMD capability packages based on a threat assessment and a determination of when the technologies needed to execute various parts of the NMD concept would reach maturity. The resultant three packages of NMD hardware needed to defeat specified threat levels were named the Capability 1, 2, and 3 architectures. Figure 2 shows the general threat levels envisioned under each capability package.

BMDO's Capability 1 architecture

While U.S. policy has long stated that the deployed NMD system might not be compliant with the ABM Treaty, the base-line BMDO plan tried very hard to make a single-site defense from Grand Forks, North Dakota, work. Although it appeared that BMDO was looking at other possible NMD sites (especially in Northern Alaska), the publicized C1 program was centered around an ABM treaty-compliant option reflecting:

- Deployment of 20 interceptor missiles at Grand Forks, North Dakota
- Locating an X-band ground based radar (GBR) within 150 kilometers of Grand Forks
- Upgrading the existing early-warning radar systems, providing them with new computers and software to enable the calculation and throughput of higher-quality near-real-time target-array location data
- Adding three or four X-band radar systems to the existing early-warning network so as to enable radar discrimination between objects within each incoming target array
- Developing a command-and-control system capable of calculating and transmitting target-

² "World Space Systems Briefing: Ballistic Missile Defense--GBI," the Teal Group, Washington, D.C., April 1998, 3.

NMD Threats, Capabilities & Defense

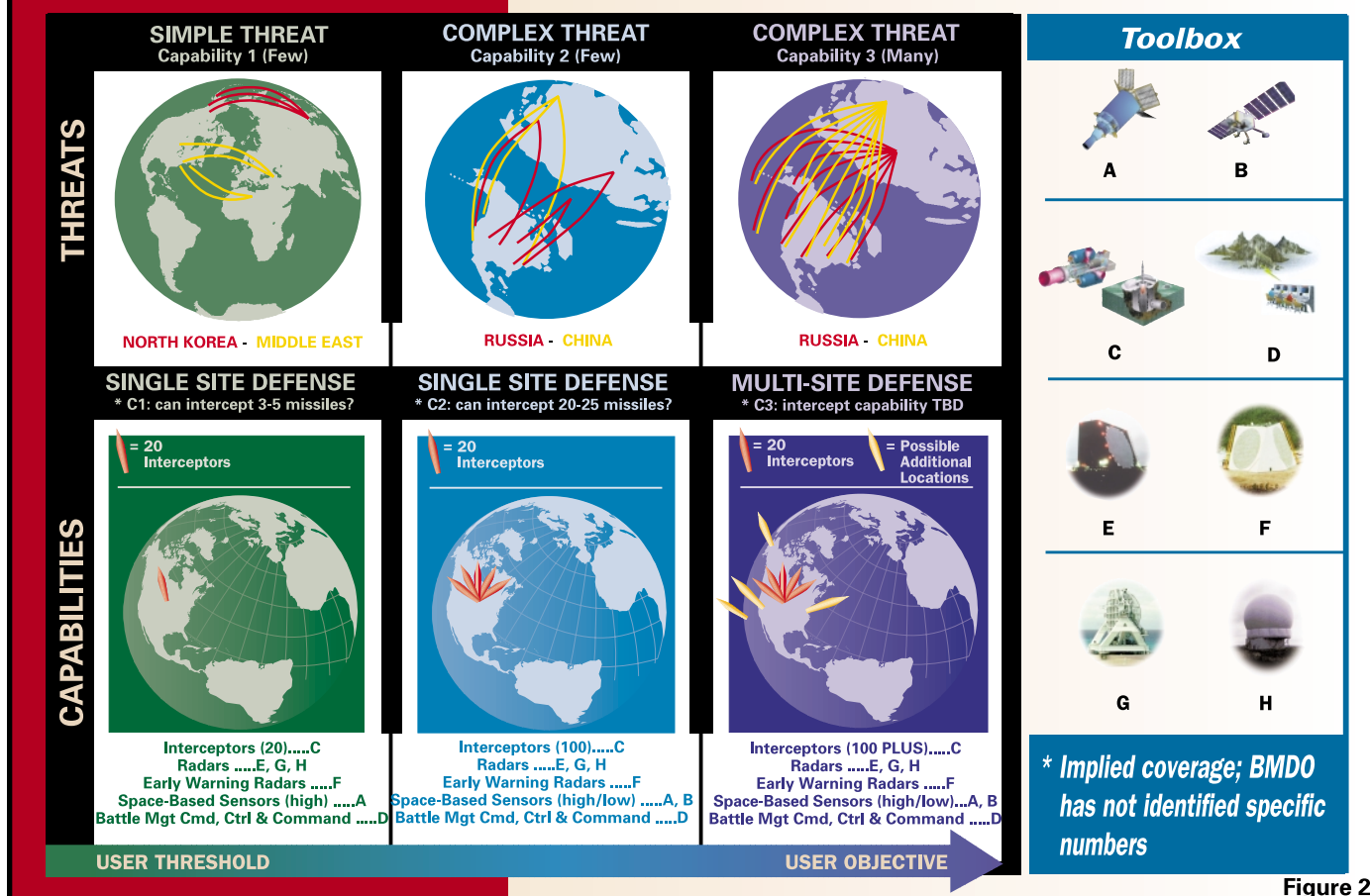


Figure 2

array data from the early-warning radar, through U.S. Space Command, through the NMD command-and-control system, to the interceptor's guidance computer

- Providing early warning for radar cueing using Defense Support Program (DSP) satellites and/or its replacement system, SBIRS-High

BMDO's C1 architecture was only a provisional plan that was to be replaced by a plan developed by the winner of the NMD lead-system integrator (LSI) contract. On 30 April 1998, the Boeing Company won the NMD LSI contract. Its design for the C1 architecture became the U.S. program for an initial national missile defense capability. Boeing's C1 design is examined later in this chapter.

Note that the LSI contract was written to facilitate rapid NMD deployment by moving selected

procurement functions to industry, thus streamlining some of the red tape that burdens government procurement operations. Under the plan, the LSI would subcontract for the development of all NMD system elements.

BMDO's Capability 2 architecture

The C2 architecture was to build on the framework established under the C1 program (or to become the base program for a later deployment). The additions to the C1 design include:

- Adding another 80 interceptor missiles to the 20 already deployed at the C1 site (for a total of 100 missiles)
- Incorporating the midcourse cold-body tracking capability provided by the SBIRS-Low satellite

lite constellation (which will facilitate an earlier launch of the interceptors)

- Adding more X-band ground-based radars to the early-warning network

Note that before 1999 much debate occurred over how to keep the C2 architecture compliant with the ABM treaty. Much effort was expended trying to find a way to field an effective missile defense at Grand Forks. Some proposed to reinterpret unilaterally the parts of the ABM treaty that prevented such a deployment. Others looked for ways to make the long-range sensory data needed for the ABM system treaty compliant technically (if not in spirit) by routing early-warning sensor information from radar and SBIRS-Low through Cheyenne Mountain. By doing so, the targeting data needed for NMD could be named early-warning information rather than ABM sensor data.

BMDO's Capability 3 architecture

Government NMD planners have always acknowledged that this option could not be implemented without abrogating or revising the ABM treaty. Essentially, the C3 architecture would:

- Consist of 100 or more interceptors (a quantity of 200 to 250 has often been discussed)
- Spread the interceptors between two or more sites
- Upgrade the sensor and battle management capabilities

Although BMDO has recently modified the C1 through C3 architectural concepts in response to the changing threat assessment, the basic structure remains as outlined in the foregoing. The modifications are being accomplished by accelerating the deployment of some parts of the basic architecture outlined above. These changes are discussed later in this chapter.

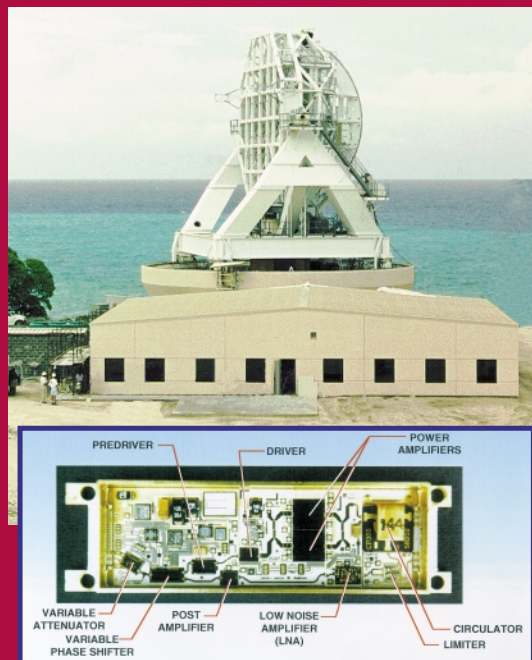
Implementing the ground-based NMD concept

The LSI contract required that a limited missile defense capability covering all fifty states be developed (20 interceptors) and, if so directed, be estab-

lished within three years of an order to deploy the system (earliest completion date: 2003). In developing its C1 plan, Boeing used the results of the two EKV sensor flyby tests (conducted just before submitting its contract proposal) to conclude that the midcourse target-array discrimination tasks could be accomplished solely by the EKV for the initial C1 system. In the two sensor flight tests, both EKV's easily discriminated the reentry vehicle from a field of nine objects of medium discrimination difficulty; they also successfully imaged the spent booster, the sun, and a star.

Thus, under the Boeing plan, the X-band radar would not be fielded as a target-discrimination sensor until the C2 upgrade is deployed. By deferring the X-band radar fielding, the unsolved problem of how to combine the three-dimensional radar and two-dimensional infrared sensor maps, using the EKV's onboard processor, to form a composite picture of the target array could be delayed until the C2 architecture is fielded, thus providing software engineers more time to solve that vexing puzzle.

X-Band Radar & T/R Module



Transmit/receive (T/R) modules plug into the radar. Additional power is achieved by increasing the number of modules used to populate the system.

Figure 3

Consequently, BMDO plans to deploy only one X-band radar set (on Shemya) for the initial NMD capability. This system will be configured to provide early warning, target-array characterization, and target-array tracking functions.³ To perform this mission, the C1 X-band radar will be populated with fewer than 50,000 transmit/receive (T/R) modules, providing it with the power needed to detect and provide a high-resolution target track of cross-Pacific ballistic missile payloads from North Korea and East Asia, but without requiring the full target-discrimination capability that the radar is capable of producing when its antenna is populated with its full complement of 78,848 T/R modules. (See T/R module diagram, figure 3, p. 4.5) The Shemya X-band and the five existing UHF early-warning radar systems will simply provide the target track files needed to target the interceptors and provide distance-to-target-array information as discussed in chapter 3.

Even though the full X-band radar capabilities will not be deployed for the initial NMD system,

the initial X-band radar can be operated and improved upon as required before the deployment of additional X-band radars in 2010.⁴ When the C2 upgrade is fielded, additional T/R modules will be added to the Shemya radar to provide it with a target-array discrimination capability.

The C1 architecture as planned by BMDO and proposed by Boeing would have established a 20-interceptor defense near Fairbanks, Alaska, or Grand Forks, North Dakota. (The sites considered are pictured in figure 4.) The advantage of the Alaskan option is that it provides the only location from which the U.S. legal requirement to defend all fifty states can be met, while the Grand Forks option provides the only location where a missile-defense system can be established under the current provisions of the ABM treaty regime (although it would still face some challenges, as discussed in chapter 2). In short, construction of the preferred Alaskan site cannot begin until the ABM treaty is modified or abrogated. Without official action on the treaty, the only site at which a missile defense legally can be established is Grand Forks, North Dakota.

BMDO had envisioned upgrading the initial C1 architecture to the C2 option around 2010 by adding another 80 interceptors to the initial deployment area as well as upgrading the kill vehicle, adding more X-band radar to the system, deploying another ground-to-space communications relay, and completing the SBIRS-Low constellation. Note that the primary technical upgrades to the system to allow it to engage highly complex target arrays occurs in this phase. Then by 2015, according to the original BMDO plan, the United States could open a second site, probably in North Dakota, with a total of 100 to 125 interceptors being deployed at each of the two sites, along with more X-band radars and another communication relay site (see figure 5).⁵

On 5 November 1999, the Under Secretary of Defense for Policy announced that the initial NMD capability, if deployed, would consist of 100 interceptors, rather than the 20 systems that had long

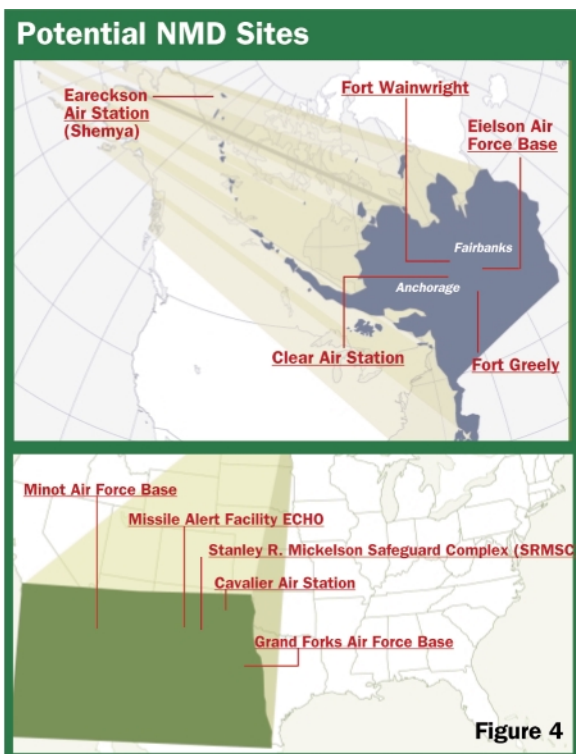


Figure 4

³ Major General Willie B. Nance, Jr., "NMD Briefing," annual conference of the Association of the United States Army, Washington, D.C., 12 October 1999.

⁴ Peller, testimony before the Subcommittee on Strategic Forces, Senate Armed Services Committee.

⁵ Michael C. Sirak, "U.S. Wrestles With Location, Number of NMD Sites," *Inside Missile Defense*, 7 April 1999, 1, 15-18.



Figure 5

been planned.⁶ When it became evident to the Department of Defense that North Korea would be able to build a significant number of ICBMs before the anticipated deployment of the C2 NMD architecture in 2010, it also became clear that a 20-missile defense capable of destroying only four or five offensive missiles would not prove much of a deterrent to North Korea's ICBM aspirations. Consequently, the number of interceptors included in

the initial NMD system had to be increased to deal with the reality of the proliferation situation. The more robust program is called Expanded C1.

The administration is now working toward deployment preparation of the Expanded C1 NMD capability in Alaska. If DoD is ordered to implement this plan, 20 interceptors would be deployed in 2005, and by the end of 2007 another 80 inter-

⁶ Walter B. Slocombe, "National Missile Defense Policy," prepared remarks at the Center for Strategic and International Security (CSIS) *Open Forum*, 5 November 1999.

ceptors will have joined the initial capability, thus providing a 100-interceptor NMD system by the end of 2007. Officials now envision that a second site with 100 more interceptors may be opened at Grand Forks in the 2010-11 timeframe.

C1 deployment preparations

The first-generation technology components provided to the NMD program office are in an advanced stage of development, as described in chapter 3. NMD program personnel believe the C1 system can be made to work against rogue-state missile threats. A real worry has been that they might not be able to debug and integrate the various components into a cohesive system within the timeframe specified. The current development situation was well described by Dr. John Peller, the Boeing NMD lead system integrator (LSI) program manager, during his Senate testimony on 24 February 1999. He stated:

*It's my opinion that this task is indeed difficult, but it is far from the formidable challenge that a lot of our critics maintain. Frankly, this project is far simpler than the challenge we had on the space shuttle. **We've caught the public eye with the idea of hitting a bullet with a bullet, which is a catchy phrase. That's not the difficult thing, the difficult thing is going to be the integration of all the stuff...** [Bold added.]*

*One thing truly unique to this program is the tremendous investment by the Ballistic Missile Defense Organization in the technology for this program. **All those dollars invested over the years have given me the best set of building blocks to start with that I've ever had... That doesn't mean that the future's easy, because we now have to pull all the stuff together and make it work together as a system as well as they do when they operate apart...** [Bold added.] As we enter this integra-*

*tion stage of the program, the risk isn't that you fail, it's the risk you don't get it done on schedule, and that is why we say we have a high schedule risk... **We are beyond the fundamental science problems.** [Bold added.] That has been a great achievement. The last fundamental science problem that remained to be demonstrated were these seeker plates [infrared focal planes]. ... With that [test] I think we are beyond the science problems [for the C1 architecture].*

***Now we are engineering ...** [Bold added.] You have to do the engineering work to fill that [technology] out. We don't worry about doing that [the engineering] successfully. ... [But] then we have to put it together into a system. It's like building a big building. You know how to do it, you know how to design it, you've got all the technology, but very often they take longer to put together than the builder had planned... **I worry about finding some subsystem that, [as] we get into it, [we find] it has a generic design defect that needs correction. ... [If] that happens to be a long lead-time item that takes a year to fix... that worries me.**⁷ [Bold added.]*

When the NMD plan was originally structured to meet the 3+3 program requirement, critics claimed that the program would be deployed with inadequately tested systems. The concern was formally articulated by the Welch report, which claimed that the U.S. missile defense programs were "rushing to failure."⁸ As a result of these concerns, the Department of Defense reviewed the NMD program, and nine additional integrated flight tests (IFTs) were added to the ten originally scheduled, for a total of nineteen IFTs. These tests are scheduled at a rate of about three per year. Two have already been conducted (IFT-3 and IFT-4), seventeen remain to be flown. Through IFT-12, prototype systems will be tested and modified as indicated by test results; begin-

⁷ Peller, testimony before the Subcommittee on Strategic Forces, Senate Armed Services Committee.

⁸ Final report of the Panel on Reducing Risk in Ballistic Missile Defense Flight Test Programs (the Welch report), 27 February 1998, 10.

ning with IFT-13, the planned production model will be flown.

As it is currently structured, the single-site C1 capability will not be operational until the end of 2005. However, both Secretary of Defense Cohen and the NMD program manager, Major General Nance, have stated that the NMD program could be accelerated for an earlier deployment if the security situation so warranted and the testing program is very successful.

Figure 6 shows the planned NMD schedule of significant events. Included in the schedule are two points where an emergency deployment decision can be made to cut short the testing program and accelerate the fielding of an initial NMD capability. Note, however, the last entry in the left column on the chart. Site preparation is shown as a three-year process. For example, the X-band radar destined to be built on the Aleutian Island of Shemya will require three construction seasons to complete.⁹ Given the strong winds that constantly

sweep that island, generating extremely low wind-chill factors,¹⁰ construction is limited to the short summer seasons. Thus, the possibility of accelerating the radar's operational date is limited should the United States determine in late 2001, for example, that an emergency security situation exists with respect to North Korea. Other weather-related construction limitations also exist for the Fairbanks, Alaska, region.

For the interceptor-launch facilities (may be split between two separate locations in the Fairbanks region), the Boeing company has taken steps to streamline silo construction requirements. Under the current plan, the silos will be prefabricated steel cylinders that will be shipped from the factory to the launch site and slid into bored holes 16 feet in diameter by 80 feet deep. The holes will be drilled using two of the world's largest crane-mounted augurs. Each augur can produce 1 million foot pounds of torque and 100,000 pounds of down force. The NMD interceptors that will fill the silos will be sealed in canisters at the assembly

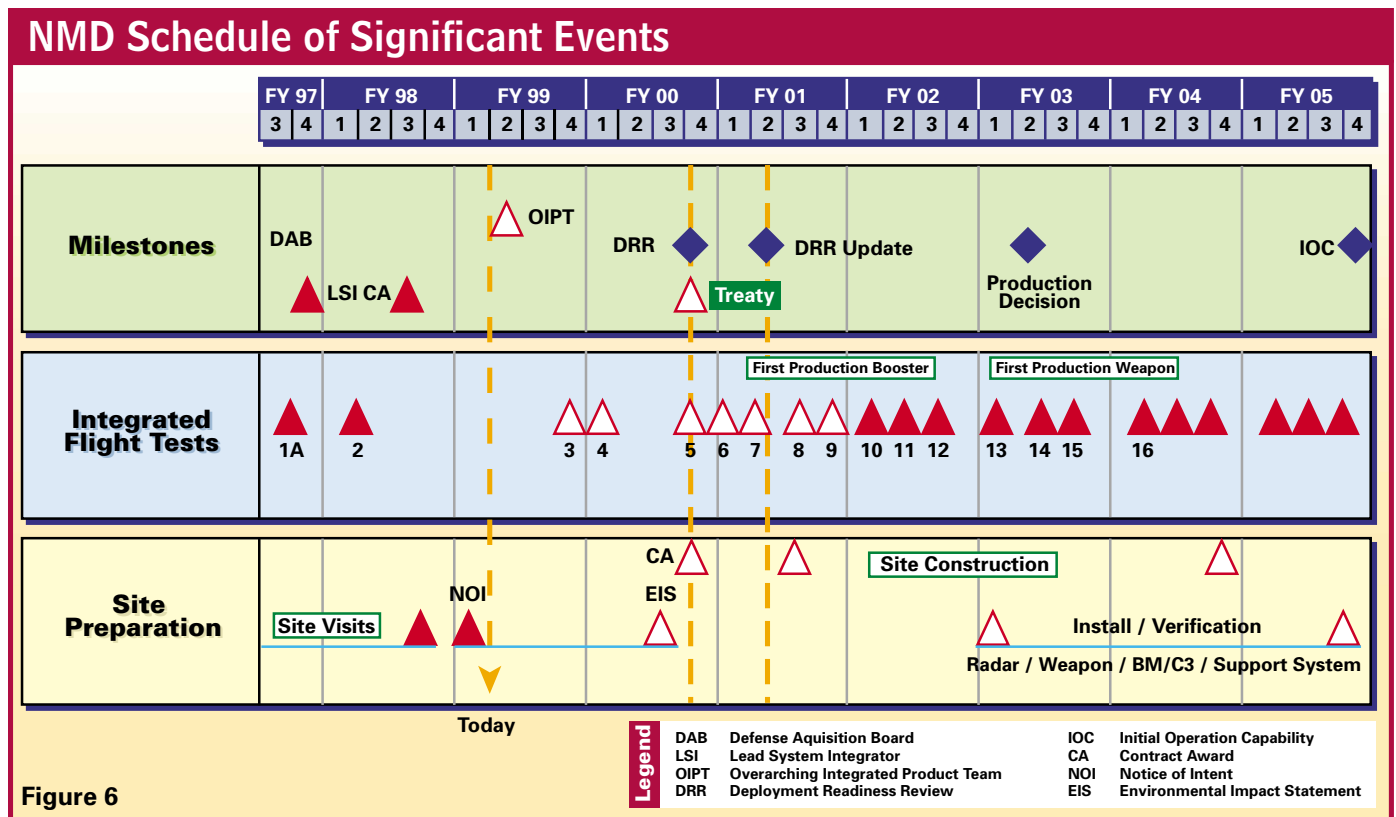


Figure 6

⁹ Nonattribution conversation with a Raytheon official, April 1999

¹⁰ "Shemya Station History," Internet, <http://climate.gi.alaska.edu/history/aleutians/shemya.html>, 3 March 1999

factory and shipped to the launch site.¹¹ The canisterized interceptor will then be quickly inserted into the steel silos. A prototype of the silo and its control room has been constructed at Boeing's Jetplex facility in Huntsville, Alabama.¹²

...test flights must be conducted in an area containing monitoring devices that provide feedback...so that malfunctions or unexpected events can be identified for correction...

– p. 4.11

The interceptors themselves are being equipped with a laser-ring-gyro inertial measurement system that will permit the interceptors to be maintained in a dormant state until just prior to launch. When a situation develops that requires an intercept, interceptor-control systems can be activated within seconds, targeting information and a current star map uploaded into the EKV's memory, and the specified number of interceptors can be launched toward their preliminary intercept points all within a very brief time span.

The initial C1 procurement order will probably be for an estimated 155 to 175 interceptors at a cost of approximately \$3 million apiece: 100 will be deployed in silos, 5 to 25 will likely be stored as spares (public knowledge of the number of spares is now uncertain given the recent revision in the numbers to be deployed), 14 are planned for use in flight testing, and 36 will be kept for follow-on test and evaluation.¹³ The stockpile of spares and test and evaluation missiles will also allow empty interceptor silos to be refurbished and reloaded within a few days of any launch event (up to the number of interceptors still on hand at that time).¹⁴ Currently, ABM treaty provisions prohibit the establishment of a rapid reload capability, which means that the reloads cannot be stored near the silos. If it were not for that restriction, the silos could be reloaded within a matter of hours.

In short, the primary NMD development tasks outstanding are to determine that the EKV can discriminate a target array and hit the selected target, integrate all of parts of the NMD system, and build the infrastructure needed for system deployment. If the United States wanted to accelerate the initial NMD program, the key elements are the success of the integrated flight tests, timely facility construction, and launch-crew designation and training.

The current pacing items: development and testing

The readiness of the technology for deployment is being judged by the test performance of the NMD system. Unfortunately, many spectators appear to be under a major misconception regarding the purpose of a flight-test program. Comments such as "the test did not replicate real combat conditions," or "the test array was so simple that the test proved nothing" point toward a misunderstanding of what a testing program is designed to accomplish. While the flight tests ultimately prove that the system is ready for deployment, the actual purpose of the exercise is to allow problems to be discovered and fixed before establishing an assembly line and going into full-scale production.

Thus, the objective is not to demonstrate on the first tests how capable the finished system will be, but rather to conduct some rather simple tasks to check critical system design factors, then build on the results by adding complexity to the tests as systems and subsystems are proven to work. Where problems are discovered, modifications are made and the results tested again. This same concept is used, for example, in aircraft development. Only a test pilot with a death wish would try to

¹¹ "Northrop Grumman's National Missile Defense Canister System Successfully Completes Development Test Milestone," P.R. Newswire, 16 August 1999.

¹² Michael C. Sirocco, "Boeing, BMW Break Ground on Prototype NMD Silo and Control Facility," *Inside Missile Defense*, 7 April 1999, 19-19.

¹³ Michael C. Sirak, "Boeing, BMDO Break Ground on Prototype NMD Silo and Control Facility," *Inside Missile Defense*, 7 April 1999, 1, 18-19; and Office of the Assistant Secretary of Defense (Public Affairs), "National Missile Defense Interceptor Booster Selected," news release no. 398-98, 27 July 1998. When the decision was made to increase the size of the initial C1 deployment to 100 interceptors, the author discussed the missile procurement requirement with the NMD program office in December 1999. The initial procurement plan called for 75 interceptors. Program personnel stated that the additional missiles needed *essentially* would just be a "plus-up to the original requirement" since the numbers needed for the testing program would remain the same. The number of additional spares needed was not clarified. Under the 20-interceptor plan, five spares were programmed.

¹⁴ *Ibid.*

push a new airplane to its combat limits on the first test flight just to prove the aircraft's combat potential to the spectators.

Similarly, the NMD test program is designed to stress the system in a progression that allows the various components to be isolated to determine if they are functioning as intended. To the extent possible, the test manager establishes backup capabilities that can substitute for any subsystem that fails during the test so that the other NMD system components can still be exercised. For example, if the X-band radar system fails, the test manager could still send target tracking data to the EKV from a missile test-range radar or GPS satellite data so that the kill vehicle, battle management system, and other system components continue to be tested during the flight.

Without a step-by-step approach, it could prove impossible to determine what caused a flight test to fail. For example, if the program manager jumped directly to a full-scale flight trial that involved hundreds and thousands of variables, it may not be possible to isolate specific design problems or to determine the severity of some indicated glitch in system performance. Similarly, without backup systems to substitute for components that may fail during testing, it would require many additional test flights to perfect a complex system of systems.

In addition, the test flights must be conducted in an area containing monitoring devices that provide feedback on each step of the structured test so that malfunctions or unexpected events can be identified for correction, even in cases where the test was successful in terms of hitting the target. In the case of the NMD tests, the target's flight trajectory must be manipulated so that the intercept occurs near the U.S. Army's missile test range on Kwajalein Atoll (Marshall Islands). Without test-range facilities and capabilities, the program manager could not obtain high-quality radar and IR measurements of the intercept attempt, nor the telemetry data transmitted by the target vehicle, the kill vehicle, and, at times, the decoys. It is the

massive collection of information that permits a reconstruction of test events to identify system anomalies. Without range support, the program manager could conduct hundreds of NMD flight tests and never determine why the system failed to perform as expected.

Integrated flight test-3 (IFT-3), October 1999

Unlike the IFT-1a (1997) and IFT-2 (1998) flyby tests to determine the capabilities of the Boeing and Raytheon EKV sensors, IFT-3 was designed to test the EKV's capabilities to discriminate a simple target array (independent of outside cueing) and to execute the commands necessary to intercept the object identified by the kill vehicle as being the reentry vehicle under conditions involving a slight cross-trajectory intercept situation (not a head-on approach, which made it a more difficult divert situation).¹⁵ As discussed in chapter 3, a single-color IR sensor will tend to identify the most radiant object in a target array as the reentry vehicle, but a multicolor IR sensor, such as the EKV uses, can perform a signature analysis of the objects in the array to identify the reentry vehicle.

To test the EKV's capability to discriminate a target array with altered characteristics, three objects were included in the IFT-3 target set. A dummy medium reentry vehicle (a cone approximately two meters long by less than 1 meter in diameter at the base), a 2.2-meter metal-coated balloon, and the spent booster.¹⁶ The RV was the smallest object in the array, it was also the object with the least amount of infrared radiance (the coldest object).¹⁷ A primary objective was to determine if the EKV's multicolor sensor system could discriminate the RV. In essence, this test was a first-level check on the EKV's discrimination and interception programming and system capabilities.

At the same time, the prototype X-band radar on Kwajalein and the upgraded early-warning test-bed radar at Beale AFB tracked the ICBM and interceptor flights in a shadow mode so that the data derived by those two systems could be compared

¹⁵ Major General Nance, "NMD Briefing."

¹⁶ Michael C. Sirak, "Next NMD Flight Test To Feature Less-Complex Target Suite," *Inside Missile Defense*, 29 December 1999, 1, 16-17

¹⁷ Major General Nance, "NMD Briefing."

with the information recorded by the Kwajalein range-control systems. The test exposed a glitch in the X-band radar's programming that caused the radar to track the target intermittently.¹⁸ That problem was subsequently fixed.

The EKV was launched by a payload-launch vehicle rather than the commercial booster that will be used for the final system configuration (figure 7). The test-launch vehicle consists of the two upper stages of a Minuteman missile and is controlled by its own guidance system. As described in chapter 3, the fielded NMD booster will be controlled by the EKV. Since that booster has not yet been integrated into the interceptor system, the EKV's ability to control the boost phase is not yet a testable task. Thus, on the initial test flights, the NMD Joint Program Office (JPO) has taken steps to increase the probability that the surrogate booster and booster guidance system releases the EKV at the correct point in space to begin its flight test. Beginning with IFT-7, the EKV will also control the booster, allowing that aspect of the system to be tested.

While the EKV selected and hit the correct target, IFT-3 revealed some problems. Apparently, the EKV may have been loaded with the wrong star map prior to launch.¹⁹ Since no booster ever delivers its payload with 100 percent accuracy and the EKV must locate its target array based on information provided by external sensors, accurate navigation is required if the EKV is to find a small target cluster in the vastness of space. In this test, the desired degree of navigation precision did not occur.

During the boost phase, the EKV tracks its own location using an inertial measurement unit (IMU); unfortunately, all IMUs develop location errors over the course of a flight. To correct IMU inaccuracies, the EKV takes two star sightings en route to its intercept point. To do this, the EKV points its seeker telescope toward a designated star, and the star images recorded by the EKV are compared to a stored star map (uploaded into memory just prior to launch). Based on the comparison, EKV position corrections are calculated. The EKV performs the second star shot just three or four minutes prior to intercept.²⁰ In IFT-3, the course correction from the stellar navigation system did not occur.

Without updated navigation information, the IFT-3 EKV approached the target complex slightly off course. When an EKV approaches the projected intercept point, it apparently rotates its seeker in a search pattern to locate the target array.²¹ In IFT-3, the EKV could not find the target complex at first. Then it detected the 2.2-meter balloon at the edge of its search pattern. Failing to find a reentry vehicle in the path of its trajectory (and since the EKV is designed to hit something in the target array if it cannot find the RV), it turned toward the balloon

and, as it moved closer, detected the dimmer object, the RV. It identified the RV as the target and diverted to make a successful intercept.

In a normal approach, the target array is centered in the EKV's trajectory. It detects the brightest and largest objects in the array first, and does not detect dimmer and smaller objects in the array until it moves closer. What is unknown in the case

EKV Payload Launch Vehicle



Figure 7

¹⁸ Sirak, "Next NMD Flight Test To Feature Less-Complex Target Suite."

¹⁹ James Glanz, "Flaws Found in Missile Test That U.S. Saw as a Success," *New York Times*, 14 January 2000, p. A1.

²⁰ Thomas Duffy and Michael C. Sirak, "Initial Analysis Shows Malfunction in NMD Kill Vehicle's Sensors," *Inside Missile Defense*, 26 January 2000, 10.

²¹ Michael C. Sirak, "NMD Office Maintaining Delivery Date for Next Kill Vehicle," *Inside Missile Defense*, 26 January 2000, 9.

of IFT-3 (classified information) is how close the EKV was to the target array before it detected the RV. The major interest in this point is that the size of the EKV's potential divert envelope is determined by that distance (see chapter 3).

Notwithstanding the problems uncovered, the EKV's seeker and the control module were able to detect the target array and destroy the correct target under more adverse conditions than had been planned. The test showed that the software controlling the EKV seemed to be working correctly. In addition, Raytheon's EKV development team determined that the EKV had more time than originally believed to conduct a search for the target array. Subsequently, the size of the EKV's target location search pattern was increased, so that in the future nearly twice as much area will be scanned as the EKV approaches its projected intercept point.²²

Note that the Boeing EKV (described in appendix C) was being maintained and worked on as a backup replacement for the Raytheon EKV in case the latter proved flawed. The sensors used by these two systems differ in that Boeing's IR sensor uses a different material for its focal plane array, a material that is cooled to a colder temperature and has a wider IR sensitivity range than does the Raytheon system, but the Raytheon system has a visible-light sensor, a capability that the Boeing system lacks. The NMD JPO program manager, General Nance, was under cost pressures to make a decision on whether or not to continue funding work on the Boeing EKV design.²³ The distance at which the Raytheon sensor detected the reentry vehicle in IFT-3 (a distance not publicly disclosed) undoubtedly was a key factor in his deliberations. It is also a reason why the NMD test program

probably included some decoys in the early test flights rather than only a single object for the EKV to hit. Target-array discrimination and the ability to detect dim targets are the most difficult capabilities to be verified in these tests.

Integrated flight test-4 (IFT-4), 18 January 2000

...the flow of krypton gas needed to pre-cool the IR focal planes prior to insertion of the liquid nitrogen that further reduces sensor temperature to under 40° K was blocked by ice that had formed in an orifice.... In IFT-4, the EKV was blind during the end game.

– p. 4.13

This test used the X-band radar prototype on Kwajalein and the upgraded early-warning test-bed radar at Beale AFB to track the target and develop missile-track files necessary for an EKV intercept. The target array used in this test duplicated the one used for IFT-3. Both NMD radar systems reportedly performed well during the course of the test. The EKV was delivered into a good intercept trajectory by the payload-launch vehicle. The EKV performed two star sightings

and was heading toward the center of the target complex but, in the end, missed its target.

The post-flight investigation found that the flow of krypton gas needed to pre-cool the IR focal planes prior to insertion of the liquid nitrogen that further reduces sensor temperature to under 40° K (-233 degrees Celsius) was blocked by ice that had formed in an orifice of the plumbing that conveys the gas to the sensors.²⁴ Without cryogenic refrigeration, the IR sensors cannot detect cold targets.

In the Raytheon EKV design, the visible-light sensor detects the target array at a long distance (provided that the array is not on the dark side of the earth) and guides the EKV toward the center of the group of objects detected. Within a time window indicated to be about six to ten seconds before intercept, the IR sensors take control of the flight, discriminate the target array, and guide the EKV into the object calculated to be the reentry vehicle. In the event the target is not sunlit, the IR

²² Ibid.

²³ Michael C. Sirak, "DOD Still Plans Next NMD Mission As Integrated System Test," *Inside Missile Defense*, 9 February 2000, 12.

²⁴ Bradley Graham, "Leak Foiled Missile Test," *Washington Post*, 8 February 2000, pp. A1, A6; and Michael Sirak, "Next NMD Test Slipped to June, Review to July," *Inside Missile Defense*, 22 March 2000.

sensors perform both the detection and the discrimination roles.²⁵ The advantage of the visible-light sensor is that in those cases where the target is in sunlight (the more likely situation given trajectory altitudes and related factors), target detection occurs at a longer range than can be accomplished using IR alone.

The most critical observation of the National Missile Defense Review of November 1999 appears to be that the NMD program is hardware poor.

– p. 4.14

In IFT-4, the EKV was blind during the end game. Raytheon engineers are reviewing the procedures used to load the cryogenic gases needed to cool the IR sensors to prevent contamination by atmospheric moisture. They are also reviewing ways to prevent a single failure from causing the entire system to fail.

IFT-4 showed that the integration of the various NMD elements was proceeding well and the shortcomings discovered in IFT-3 had been corrected, but it also uncovered a cooling system problem. Unfortunately, IFT-4's failure to intercept its target increases the political pressure on IFT-5.

According to the NMD deployment standards, two successful intercepts must be demonstrated before the President would be asked to consider a decision to deploy the NMD system.²⁶ So far, only IFT-3 has fulfilled the interception requirement. With IFT-5 postponed from April 27 to July 7, 2000, the Pentagon will not be able to review the test results until late July at the earliest. There is some speculation that the current administration might run out of time and leave office without making a deployment decision on the NMD system.

Testing concerns

The second Welch report took issue with a number of aspects of the NMD development pro-

gram. Some issues raised were specific administrative issues that are outside the scope of this study. Other issues dealing with hardware and testing, however, point toward potential problems that must be considered.

The most critical observation of the National Missile Defense Review of November 1999 appears to be that the NMD program is hardware poor.²⁷ This shortcoming drives a number of other issues in the NMD development program, including:

- **Components used in stressful ground tests often are used in a flight test, even though they may have been stressed beyond their design limits prior to flight.** For example, EKV thrusters are designed for a one-way trip to an intercept point. Yet, they may have been fired many dozens of times in ground tests, increasing the risk of failure during flight due to metal fatigue. For example, a car designed for 100,000 miles of driving might not be very reliable when it has 300,000 miles on the odometer. The same holds true of some EKV components. In another case, an IMU for the EKV was tested for shock by ramming it with a steel ball dropped perhaps forty or fifty times from heights varying between three and six feet. In this case, the IMU did not break, and it was used in the IFT-3 EKV.²⁸

In other tests, the focal plane arrays have been repeatedly cooled and warmed, an action that induces abnormal thermal stresses in those sensitive devices.²⁹ In a fielded configuration, the only time the focal plane will be subjected to thermal stress is when it is cooled to 40 degrees above absolute zero en route to the intercept point. Repeated cycles of cooling and warming artificially stress the EKV's sensor suite and add an abnormal element of uncertainty into the flight testing program. More NMD system equipment is needed for test and evaluation.

²⁵ Michael C. Sirak, "NMD Officials: Short of Intercept, System Did Well in Recent Test," *Inside the Army*, 14 February 2000.

²⁶ Michael C. Sirak, "NMD Can Be Fielded After Two Successful Test Intercepts," *Inside Missile Defense*, 28 September 1999, 1, 17-18.

²⁷ Panel on Reducing Risk in Ballistic Missile Defense Flight Tests Programs, *National Missile Defense Review Committee Report* (the second Welch report), 16 November 1999.

²⁸ Bradley Graham, "Missile Shield Still Drawing Friends, Fire."

²⁹ Ibid.

- **Hardware shortages limit parallel testing in ground facilities.** The Welch report cited a need for more extensive ground-based testing to ensure that the NMD system, and particularly the EKV, is capable of performing its mission in all possible situations. The report pointed out that the intercept angles used to accommodate the Kwajalein test-range boundaries do not permit other angles of intercept to be flight tested. It recommended other testing regimes to increase the range of situations used to challenge the NMD system.

Examples cited include a recommendation that the EKV be tested in a special ground facility that would allow different angles of intercept under varying attack situations to be simulated. Likewise, the X-band radar prototype at Kwajalein could be tested more completely by using air- and sea-launched missiles to generate tracking targets throughout the full range of its search envelope. In short, the Welch committee recommended that a larger set of scenarios and situations be tested. However, without more sets of equipment on hand, the committee noted the difficulty of conducting parallel testing at multiple locations. The program teams spend too much time shuttling one or two pieces of equipment between multiple locations. This shortage limits the testing program and slows development.

Related to the testing issue, the Welch report highlighted two concerns:

- **The salvo engagement capability cannot be tested because of the lack of a second launch pad at Kwajalein.** Currently, the Kwajalein range facility has the capability of launching only one NMD interceptor at a time. However, most NMD engagements will involve the salvo launch of multiple interceptors. The capability to test the NMD's ability to handle multiple simultaneous missions needs to be tested before system deployment. The Welch committee recommended that a second launcher be constructed at Kwajalein to support testing of salvo launch capabilities.
- **The EKV's ability to withstand the much higher flyout stress generated by the commercial booster needs to be tested in advance.** Once the planned booster is integrated into the inter-

ceptor system for IFT-7, the launch stress that the EKV must be able to withstand will be much higher than is now produced using the substitute payload-launch vehicle. The committee was concerned that if a problem should be uncovered it could delay the program.

More funding has been allocated in the administration's 2001 budget request and five-year defense program (FYDP) to correct some of the NMD program deficiencies cited above. However, even if the funding is approved and made available, procurement of the needed hardware items will require time. The Welch report pointed out (indirectly) that one of the costs of not properly funding the NMD program in previous years is that it may prove difficult to accelerate the program for a deployment earlier than 2005.

Overall NMD system capability: what will it be able to defend against?

The bottom line for the deployed NMD system will be how many missiles the system will be able to defend against. If the United States has the capability of intercepting only a very limited number of ballistic missiles, that condition could entice missile proliferators simply to outbuild U.S. defenses, spurring rather than deterring rogue-state efforts to build more ICBMs. Thus the question of how many warheads the planned NMD system is capable of destroying is a key issue.

The potential effectiveness of the planned NMD system hinges on several related variables, including the technology issues already discussed. Although the technology is important, so is the basing location of the interceptors in relation to the anticipated threats and the criteria established for required system effectiveness. These latter two issues determine how many interceptors have to be expended on the various missions. Obviously, if a large number of interceptors are required to destroy each missile

...the number of interceptors officials cite as being needed to kill a reentry vehicle is an averaged number not applicable to all attack scenarios.

– p. 4.15

threat, the overall NMD system will be able to defend against fewer missiles than would otherwise be the case.

The general factors that govern overall system capabilities include:

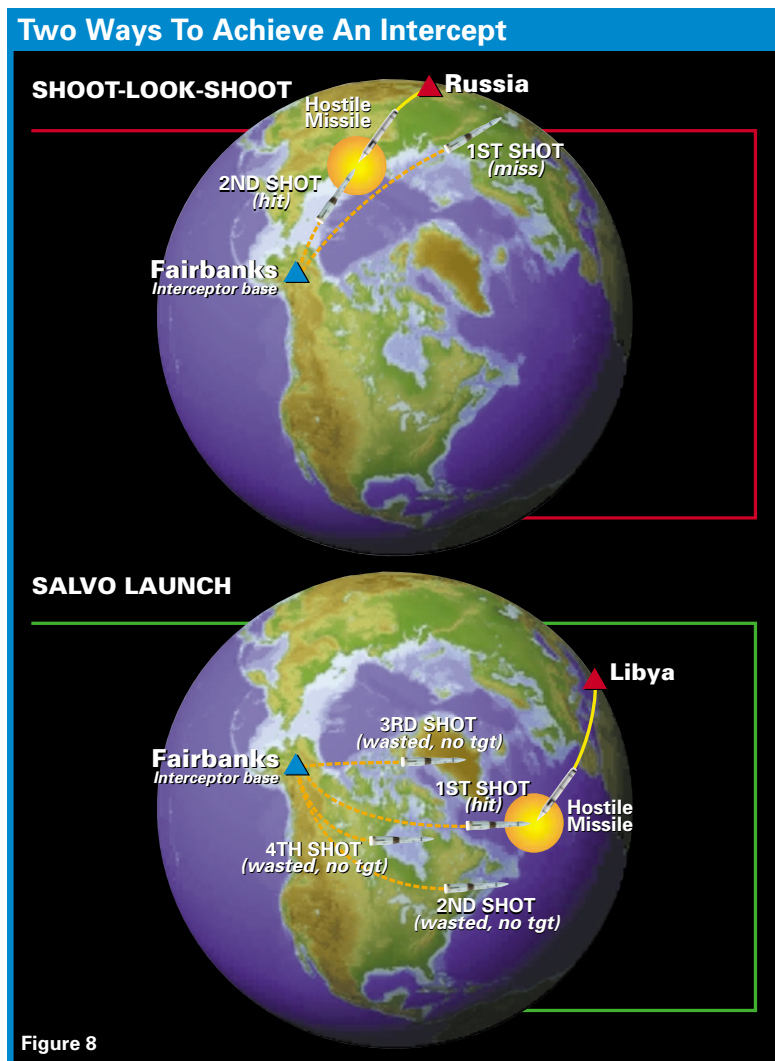
- **The potential for using shoot-look-shoot engagement methodology** versus salvo engagement.
- **Early identification and determination by the NMD battle manager of target array complexity.**
- **System reaction time:** launch detection, target tracking, interceptor launch, and flight times of the offensive missiles and the defensive interceptors.

Each of these categories requires some elaboration since they are the essential elements for assessing the potential effectiveness of the administration's proposed NMD plan.

System probability of kill requirement

It appears likely that the NMD requirements document specifies that the system must be able to destroy specified types of incoming warheads based on a kill probability of $pK=0.99$ or perhaps 0.999. The threats defined by the NMD mission statement against which to calculate the kill probability include rogue-state threats and, to the extent possible, accidental launches from established nuclear powers.³⁰ Officials have noted on numerous occasions that a 100-interceptor force should be able to defend against 20 to 25 reentry vehicles.

Unfortunately, the number of interceptors officials cite as being needed to kill a reentry vehicle is an averaged number not applicable to all attack scenarios. For example, an accidental launch of a sophisticated Russian missile would require many more interceptors to achieve a probability of kill of 0.99 than would the launch of an unsophisticated first-generation ICBM. Likewise, a poor angle of interception, due to the particular geometry of the offensive missile's trajectory in relationship to



- **The required level of assurance that reentry vehicles have been destroyed.** The requirement is expressed in terms of probability of kill (pK).

³⁰ For example, see Lt. Gen. Lester Lyles, testimony before the Subcommittee on Strategic Forces, Senate Armed Services Committee, 24 February 1999. In addition, Dr. Charles Infosino hinted at a 0.999 figure at IFPA symposium *Assessing National Missile Defense*, 5 May 1999. Conversely, an article in a respected trade publication claimed that the system had to be effective to the 95 percentile level. This figure is less than BMDO officials (who also claim that the actual number is classified) have indicated. Adding weight to the probability that the number is higher than 0.95 is that fact that during a Capitol Hill workshop, the program executive officer (PEO) for Army Theater Missile Defenses stated that the pK for the THAAD system was 0.99. Brigadier General Daniel Montgomery, "Theater Missile Defense Briefing," Institute for Foreign Policy Analysis workshop (Capitol Hill, Washington, DC), 28 April 1999. It seems unlikely that homeland defense would rate a lower threat kill probability than does theater defense.

the interceptor's trajectory (such as perpendicular, crossing trajectories), would produce an unfavorable divert envelope for the EKV and reduce the single-shot kill probability. In this situation a larger number of interceptors would be needed to achieve a $pK = 0.99$ requirement.

Shoot-look-shoot versus salvo launch

Essentially, this engagement decision is driven by simple time-distance calculations. The preferred method of engagement is shoot-look-shoot. This means that one or two interceptors are launched, the defense waits until the EKV(s) reach the intercept point, the battle manager determines whether or not the intercept was successful, and then, if necessary, launches again. The alternative is to identify a target, calculate how soon an intercept attempt could be made, then determine, if the first attempt should fail, whether there is time for a second attempt before the missile detonates. If the answer is no, the battle commander must launch the number of interceptors required to meet the pK requirement. As shown in figure 8, this could mean that the first interceptor destroys the target and the trailing three or four systems are wasted.

Obviously, the greater the number of missions that could be executed using shoot-look-shoot, the greater would be the overall capability of the NMD system. For example, if 70 to 90 percent of the incoming warheads could be destroyed by the first interceptor launched against each reentry vehicle, the fielded NMD force could defend against a significantly higher number of threat objects than would be the case if salvo-launch tactics had to be used for most engagements.

Early identification and determination by the NMD battle manager of target array complexity

The battle manager must be able to determine what type of warhead is inbound: how many reentry vehicles are involved, how advanced is the penaid suite? These questions are particularly important in cases where the trajectory to be intercepted is too far away from the interceptor bases to allow a shoot-look-shoot engagement. If the NMD battle manager has to use salvo engage-

ment tactics, that individual must ensure that enough interceptors are launched to destroy all reentry vehicles and any decoys that cannot be identified as decoys. Without adequate information on the target array, the battle manager will likely error on the high side, wasting interceptors that might be required later.

For the initial NMD deployment, the battle manager will depend on intelligence files that catalogue country and missile system capabilities. For example, if high-altitude sensor systems detect a missile launch in Libya heading in the direction of North America, and the IR signature indicates the missile is a North Korean-manufactured *Taepodong II*, the NMD battle manager will make target assumptions based on that information. Once the upgraded early-warning radar begins tracking the launch, the battle manager will at least confirm how many target clusters have been released. After the SBIRS-Low system becomes operational around 2010, that information will also be available to the battle manager to assist in the target-array assessment.

Target array tracking and its implications for engagement tactics

As noted in chapter 3, an effective NMD system requires early target detection and tracking, but the earth's curvature limits the effective range of ground-based radar. Since SBIRS-Low is not projected to be operational until 2010, the United States will be depend entirely on ground-based radar for the target-track files needed to steer an intercept. In a few cases, the delay in establishing a target-track file could result in a salvo-launch engagement methodology being required because there will not be enough time remaining in the missile's flight once the radar track file is built for a shoot-look-shoot engagement. In other cases, however, the absence of SBIRS-Low will not make any difference in engagement methodology. Salvo launches will have to be used in the

For the initial NMD deployment, the battle manager will depend on intelligence files that catalogue country and missile system capabilities.

– p. 4.17

event that the interceptor bases are located too far away from the threat trajectory to use shoot-look-shoot tactics.

In short, the effectiveness of the NMD system will be determined by an interaction between its basing location in terms of time-to-distance intercept calculations, the effectiveness of the technology and

Libyan and North Korean case studies

The following two case studies use hypothetical missile launches from Libya and from North Korea to illustrate the above factors in action. The cases are prefaced by a brief description of some basic rocket science to provide background for these case studies.

A ballistic missile normally will fly a minimum energy (ME) trajectory. The ME trajectory is the flight path that achieves the longest possible range, carrying a maximum payload, and yielding the highest degree of ballistic accuracy of any of the possible trajectories that could be selected. However, in selecting the actual trajectory to be used, a missile planner can make trade-offs to optimize a specific result. For example, the planner can lower the trajectory somewhat (within an approximate 5-degree range of the missile's ME trajectory injection angle) and incur only minimal costs in range, payload, or accuracy. Military planners habitually make trajectory adjustments if such action would, for example, delay radar detection or tracking of the missile by the opposing force.

In special cases the trajectory could be depressed severely, deliberately trading off potential range and payload accuracy for a shorter time of flight and a much lower trajectory to thwart radar tracking. For example, a missile on a 7000 kilometer ME trajectory will reach its apogee at an altitude of 1200 kilometers. If the trajectory were depressed to perhaps a 500- to 600-kilometer apogee, it would cost roughly 1000 kilometers in potential range capability. Thus, a missile with a maximum 8000-kilometer range capability using the ME trajectory will

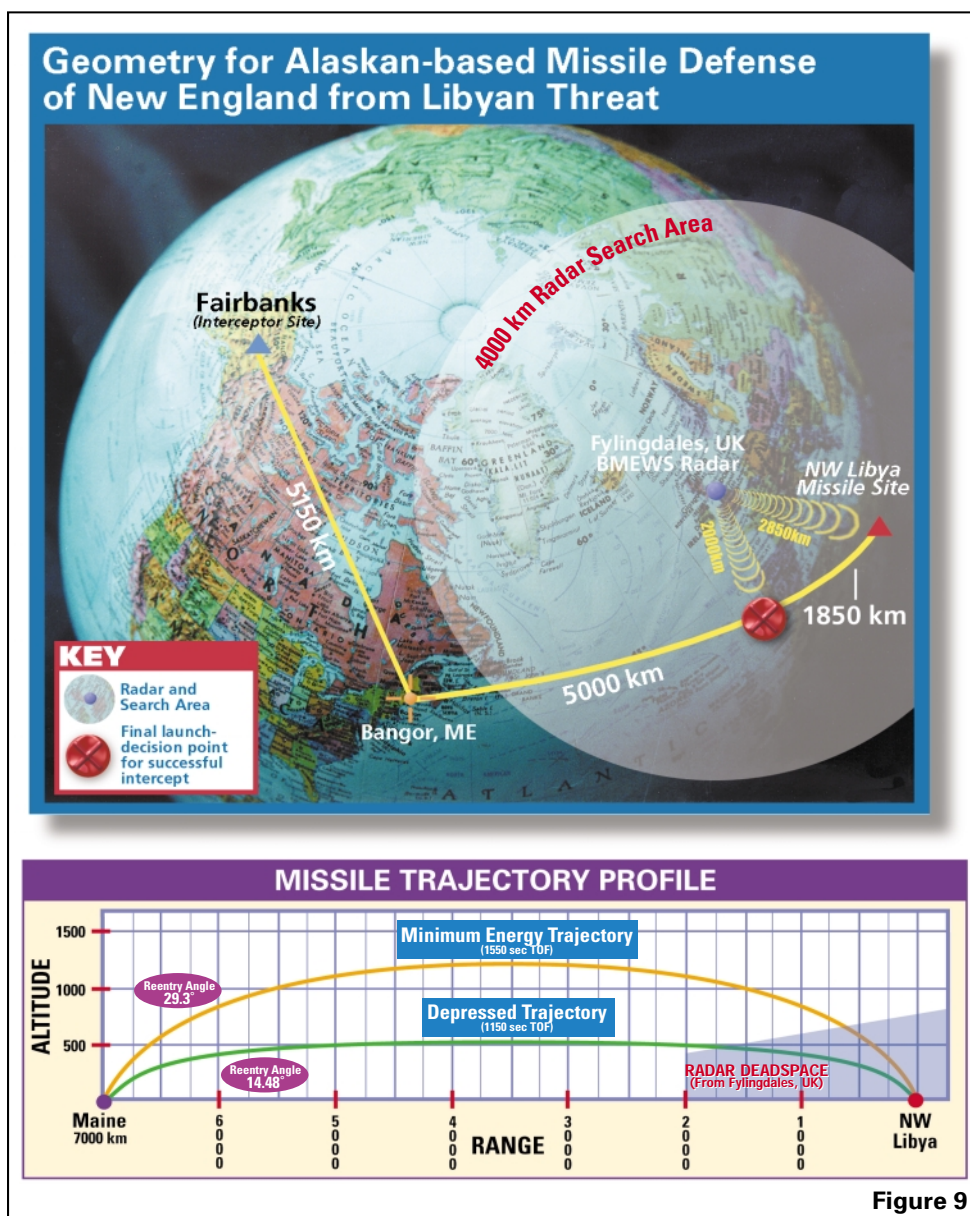


Figure 9

systems deployed, and accurate information in the hands of the NMD battle managers on the current status and capabilities of offensive missile and warhead deployments.

trajectory were depressed to perhaps a 500- to 600-kilometer apogee, it would cost roughly 1000 kilometers in potential range capability. Thus, a missile with a maximum 8000-kilometer range capability using the ME trajectory will

only be able to achieve 7000 kilometers using a depressed trajectory. However, if the full range capability of a missile is not required to reach the designated target area, the only real trade-off would be accuracy.

Depressed trajectories are much less accurate than ME trajectories. The lower flight profile translates minor errors in missile guidance into large errors in range. These errors potentially could result in missing the target by perhaps as much as 100 or 200 kilometers. However, technological improvements in midcourse guidance technology (such as GPS) may allow emerging missile powers to develop the means for using depressed trajectories to deliver missile payloads with much greater accuracy than has heretofore been the case.³¹

Depressed trajectories also have the advantage of shorter flight times. For example, the ME trajectory in the example given above would have required roughly a 25 percent longer flight time to reach the target area than would the same attack using a highly depressed trajectory. The shorter time of flight would improve the chances of delivering its payload without being intercepted. On the other hand, since depressed trajectory payloads spend longer periods of time within the earth's atmosphere, the warhead section would be subjected to greater heating effects than is the case with an ME trajectory. In most cases, however, the additional heating effects should be manageable.³²

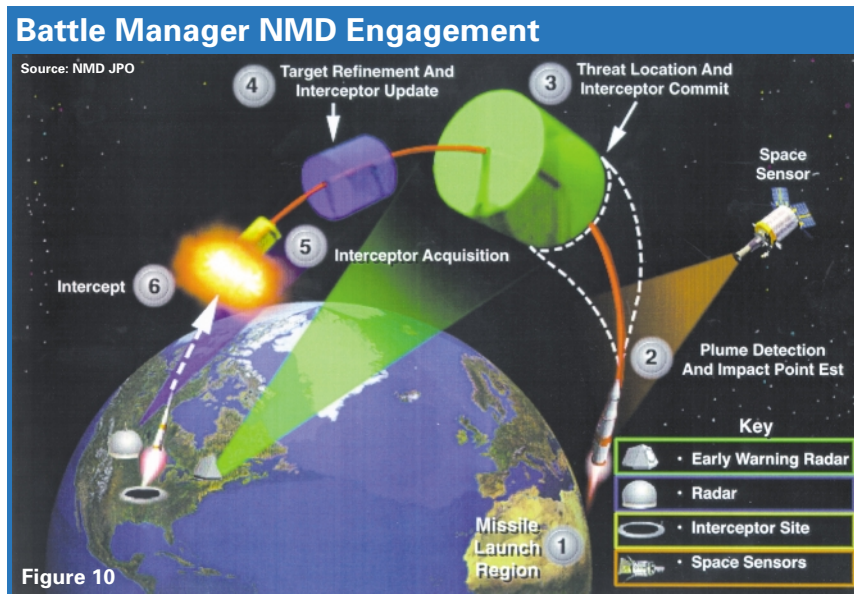
The Libyan example

Figure 9 depicts the radar and trajectory geometry of a hypothetical Libyan missile launch against the New England region, where a ballistic missile is launched from an inland site near the Algerian border

south of Tripoli. Although Libya could launch from anywhere in the country toward any part of the United States, the most challenging NMD scenario is the defense of the Maine-to-Boston region from the firing location selected.

For a Libyan missile to win a race to New England without being intercepted by an Alaskan-based system, it must pass the red-X area in figure 9 before the Alaskan interceptor is launched. In this example, the Libyan missile must fly 6850 kilometers to Bangor, Maine, before the Alaskan-based interceptors can travel 5150 kilometers or more to make the intercept.

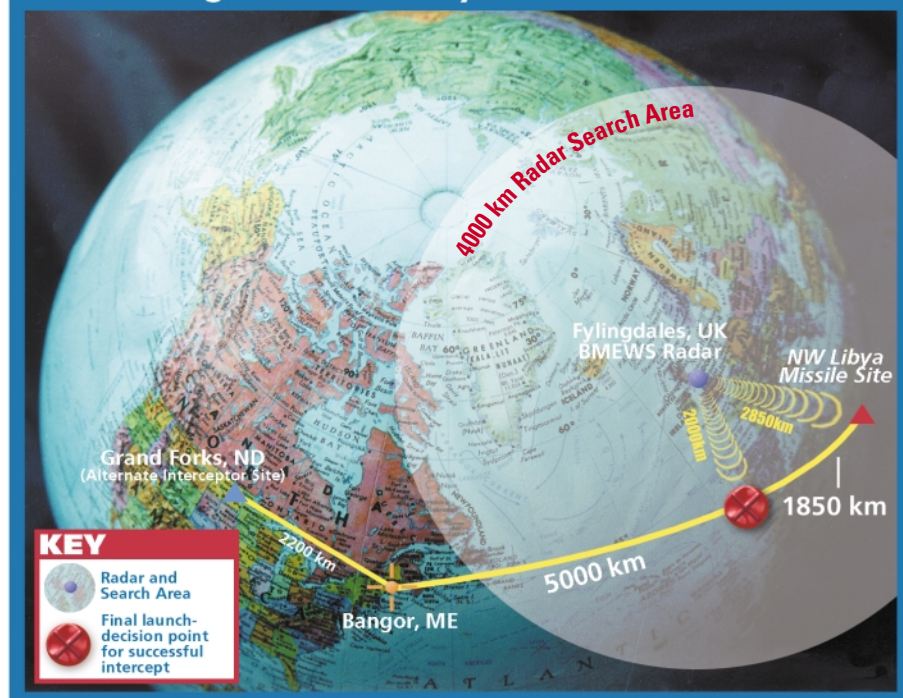
In this case, the key will be how soon the preliminary target track can be established and the interceptors launched. It is about 2850 kilometers from the early-warning UHF radar at Fylingdales to the selected Libyan launch site. Because of the earth's curvature, a missile cannot be detected at this range until it reaches an altitude of about 750 kilometers. By the time the missile reaches the west coast of Portugal the radar range decreases to 2000 kilometers and the



³¹ Use of GLONASS and GPS navigation satellites to correct missile midcourse flight paths is becoming a common practice for Russia, China, India, and the United States; the practice is likely to spread to other states within the next few years in light of current proliferation. In addition, stellar navigation technology is also likely to spread, which will contribute to the proliferation of midcourse ballistic missile trajectory correction capabilities. These technologies will act to increase the probability that more states could use depressed trajectories for planning ballistic missile attacks against the United States.

³² The information on trajectories was developed from several hours of conversations with three rocket scientists on a nonattribution basis; and Roger R. Bate, Donald D. Mueller, and Jerry E. White, *Fundamentals of Astrodynamics* (New York: Dover Publications, 1971), 19-41.

Geometry for Grand-Forks Based Missile Defense of New England from Libyan Threat



If the missile is flying a ME trajectory, as shown at the bottom of the figure, the trajectory should be detectable by radar at around 600 kilometers from its launch point (near or soon after booster burnout), a track file should be established by the time the missile reaches the 1000-kilometer range mark. In this example using the ME trajectory, the first EKV should reach the incoming warheads approximately 400 kilometers east of the New England coastline, with successive attempts by trailing interceptors occurring ever closer to U.S. territory. Obviously, the battle manager needs to launch as soon as a preliminary track file is determined.

However, if Libya uses a depressed trajectory, similar to the one shown in figure 9, the radar track file might not be established until the missile is nearly 2000 kilometers down-range (in the vicinity of the red X). The radar should be able to establish the track file after perhaps thirty to fifty seconds of radar contact (about 200 or so kilometers of flight). Unfortunately, as shown in the Fylingdales radar sector diagram in

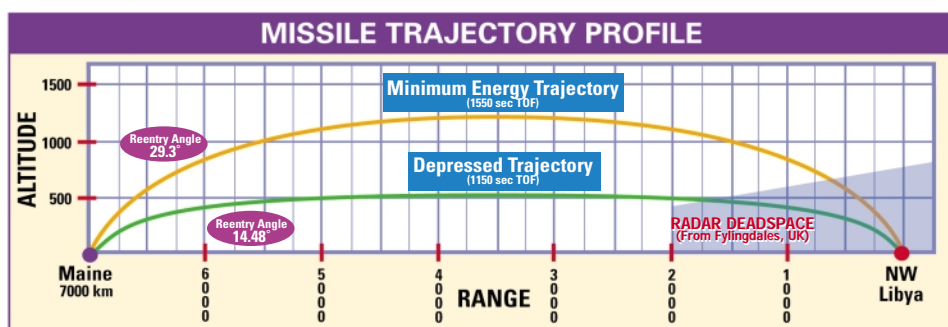


Figure 11

chapter 3, a Libyan missile in the vicinity of the Strait of Gibraltar would be well off the boresight axis of the southwest face of the Fylingdales system, thus it could require up to twice as long to establish a track file (perhaps 400 kilometers or more of missile flight distance after radar detection of the target). Obviously, the NMD battle manager cannot wait to receive a radar track file before launching the interceptors.

Once a Libyan missile passes the western coastline of Portugal it will be about 5000 kilometers from Bangor, Maine, traveling at a velocity of 6.5 to 6.8 kilometers per second. Although the burnout velocity of the Alaskan interceptors will be faster, they require three to four minutes of boosting to reach that velocity. So for purposes of this study, we assumed that the intercept point would be roughly halfway between the interceptor base and the offensive missile's location at the time the preliminary track file is established.

In this case, the NMD battle manager will have to launch on SBIRS-High provided trajectory data. As discussed in chapter 3, SBIRS-High will provide trajectory and velocity data as of the booster

burnout location, but no radar data will be available at launch to indicate the number of target array(s) deployed. The battle manager will launch the interceptors based on the preliminary target track file from the SBIRS system. Once radar detects the target array, more accurate data can be passed to the EKV through the in-flight communications system. The EKV then makes minor corrections to its trajectory to align itself with the refined projected intercept point (figure 10). Since the missile on the depressed trajectory will arrive sooner, the margin for error is smaller.

In this scenario, the U.S. interceptors would have to use a salvo-launch engagement methodology. Thus, if the battle-management system projected that four interceptors are needed to achieve a $pK = 0.99$ intercept probability, all four interceptors would have to be launched even if it is highly likely that the first or second interceptor would destroy the target.

Establishing an interceptor site in North Dakota has similar limitations on engagement methodology. As shown in figure 11, it is 2200 kilometers from Grand Forks to Bangor, Maine. In the case where an ME trajectory is launched from Libya, again, the missile will likely be 800 to 1000 kilometers downrange before the radar track file is established and the interceptors at Grand Forks are launched. At launch, the interceptors and their target would be about 8000 to 8200 kilometers apart, and each would fly 4000 to 4100 kilometers to a midpoint roughly 1900 to 2000 kilometers east of the New England coast. If the EKVs missed, the offensive payload would be too close to New England for a second intercept attempt from Grand Forks. Thus, salvo engagement tactics would be the only option available for the defense of New England.

The North Korean example

A similar situation exists with respect to the defense of Hawaii

from a North Korean missile launch. In this scenario, the United States would only have time to ripple-launch the calculated number of interceptors required to destroy the warhead from a central Alaskan basing location. Since the X-band radar (to be established on the Aleutian Island of Shemya) will be 3500 kilometers from North Korea, the bottom of its search beam will be about 1000 kilometers above the launch site. Consequently, it is unlikely that the radar would detect a minimum-energy trajectory from North Korea to Hawaii before the missile passed the 900-kilometer-range mark. It is assessed that the radar track file could not be built before the missile reached the 1100-kilometer mark, with the interceptors launched when the target missile is roughly 1200 kilometers downrange from North Korea, or about 6000 kilometers short of Pearl Harbor.

Considering the triangular geometry involved in the intercept (see figure 12), it is clear that a salvo engagement tactic would have to be employed since a second launch from an Alaskan missile defense site would not have enough time to reach the North Korean warhead before it detonated over its target (if the first interceptor missed before the second was launched).

Distances: Defense of Hawaii From North Korean Missiles

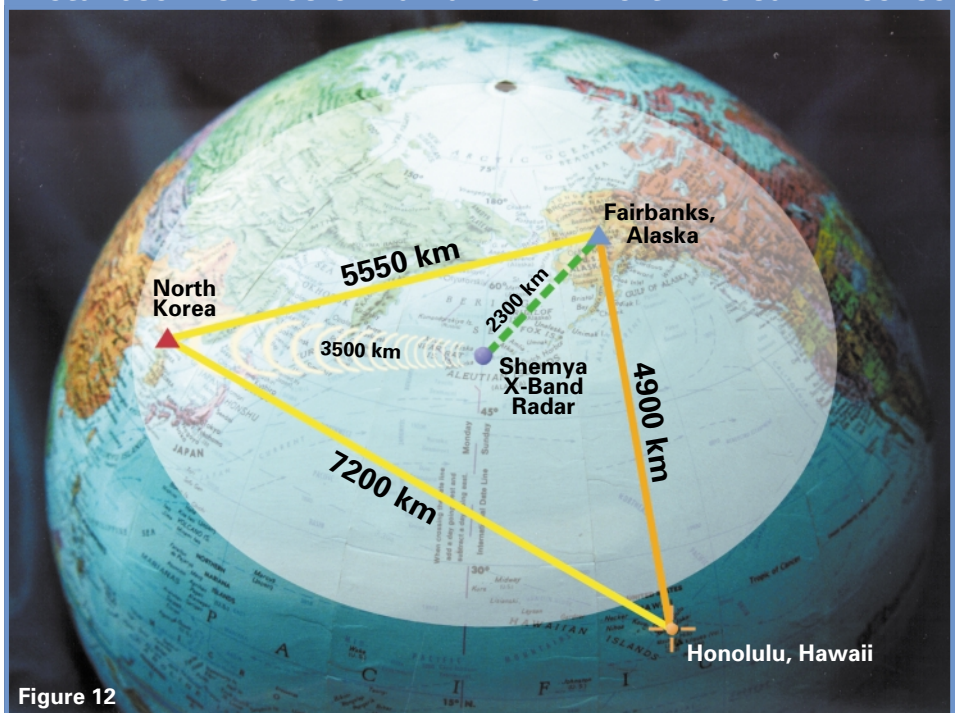


Figure 12

With the 20 missiles originally planned for the C1 capability, North Korea could have fired a mere five ballistic missiles at Hawaii (even with conventional warheads) to deplete the Alaskan-based NMD capability, then threatened WMD use against any other target it might select. With a 100-interceptor force, this option could not be used because it would undoubtedly result in a U.S. nuclear strike against North Korea well before the NMD defenses were depleted.

Putting the system together

Following is a summary of how the various elements in the NMD C1 architecture are expected to contribute to the overall system. The sequence of events traces the steps that would be taken by a land-based NMD system in response to a ballistic missile launch.

1: Initial warning of a missile launch

The first indication that a ballistic missile has been launched would likely be provided by the high-altitude infrared sensing satellite constellation (DSP/SBIRS-High). The actions that will accompany the initial launch warning include:

- Alerting the early-warning radar network to establish a search fence
- Orienting any other available satellites or intelligence-collection assets to monitor the missile
- Reviewing intelligence data on missile types known or suspected to be in the area where the missile was launched
- Analyzing the infrared spectrum profile measured by the high-altitude infrared sensors to further classify the missile launched

2: Detection by early-warning radar

The early-warning radar system should detect indications of a missile launch fairly early in the missile's flight (within the physical limitations discussed in the radar section). The early-warning radar sections would:

- Establish a radar fence as directed by U.S. Space Command
- Search for indications of the missile's location. The booster would normally be trailing the target array. Since a missile's booster has a large radar cross section (radar reflectivity of 1 to 10 meters square, depending on missile type, target orientation, and so on), the booster is likely to be the first object detected. Once the booster is located, the radar would focus more power in the direction of the booster's track and attempt to locate the target array(s). A reentry vehicle would have a much smaller radar cross section than does a booster, usually between 0.1 to 1 meter square.

If the radar is a UHF early-warning system, only the number of target arrays and their trajectory tracks would be identifiable. If the radar is an X-band system (such as the Shemya radar), the target-array tracking information would begin to be developed along with some details regarding the internal composition of the target array (as discussed in chapter 3).

- Once the target arrays are identified, the track files would be established. The track file normally is calculated within approximately thirty to one hundred seconds of the initial target-array contact (the time varies due to the vector to the target array in relationship to the radar's boresight, the relative size of the target's radar cross section, and the range to the target array). Since the X-band radar's face would be rotated in the direction of search, the boresight direction would not be an issue for that system except in cases involving multiple missile launches requiring simultaneous tracking on greatly divergent axes.
- The missile's track file would be forwarded to U.S. Space Command and the NMD Battle-Management Center.

3: Assessment and response

Using radar-track files and compiled information on the specific type of incoming missile threat, the battle-management computer system would

provide an assessment and options to the battle manager who would quickly make a number of decisions, including:

- The number of incoming reentry vehicles or suspected reentry vehicles that must be hit by an interceptor. In cases involving an accidental launch of an advanced missile, or if a rogue country were known to have procured a warhead with advanced penetration aid technology, decoys might be included in the payload of sufficient sophistication to preclude discrimination. If the decoys cannot be discriminated, they would have to be treated as reentry vehicles.

- The time-distance factors, which must be calculated in order to determine whether a shoot-look-shoot engagement methodology could be used. If the first interceptor launched could not reach its designated target in time to launch a follow-on missile if the first interceptor should miss, a rippled salvo tactic would have to be employed.

- The location of a preliminary engagement sphere in space. Once calculated, this would be fed into the interceptor's guidance system to provide it with an initial destination during the fly-out sequence. In cases where shoot-look-shoot tactics were not possible, the battle manager would look for the best-case engagement geometry to maximize the probability of kill. Some angles of attack and engagement points along the trajectory would provide more advantages to the defense than might other situations.

- The number of interceptors to be launched and the pattern/time intervals between launches. In the case of a limited shoot-look-shoot situation (for example, two chances or more to shoot), the battle manager might chose to launch one or two interceptors, look at the results, and launch again if they missed. In a shoot-look-shoot scenario, the first interceptors would return sensor telemetry data on the target

array so that the battle manager could see the array and develop a better picture of the complexity of that array before the second volley was launched.

The communication system would provide the links between the Battle Management Center and the interceptor:

...the C1 capability will be heavily dependent on the use of salvo engagement tactics. Such tactics waste resources that could be used to mount a more robust defense if more shoot-look-shoot engagements could be employed.

– p. 4.23

- Updated target location data and revised target rendezvous instructions would be sent from the Battle Management Center to the interceptor.

- Once the kill vehicle's onboard sensor suite begins searching for the target array, its telemetry module would provide sensor feedback to the battle manager. In shoot-look-shoot situations this feedback is critical in helping to determine if the kill

vehicle hit its target (that is, determining if more interceptors need to be launched).

Note that there are some questions regarding the ability of the C1 architecture to provide a reliable kill assessment. If a kill assessment cannot be made, the system will have to carry out salvo launches based on pK calculations until the C2 architecture is in place.

This examination of a hypothetical intercept sequence shows that a critical issue is the question of shoot-look-shoot verses salvo-launch engagement tactics. Clearly, the ability to engage targets with a shoot-look-shoot methodology decreases the level of risk and the eventual cost of fielding an effective national missile defense system.

Conclusion

The NMD program is designed to increase in capability as technology develops and is incorporated into the system deployed under the C1 architecture. A major surge in the technological capability of the NMD system to deal with advanced missile systems will occur when the C2 architecture is established around 2010. The C1

system will not only provide a basis for defeating a limited number of missile threats, it will also establish an initial system able to mature and improve in operational capability over time. By the time the C2 system is deployed, many of the problems that usually plague new operational capabilities will have been uncovered and solved.

As for the test program, the amount of equipment available with which to conduct robust ground simulations has been very limited to date. Funds have been requested in the 2001 budget request to address this shortage. As for the integrated flight tests, the first two went more smoothly than is generally understood. If the C1 NMD system continues to develop and perform as indicated by its initial flight tests, the system should be able to provide an Alaska-based C1 capability that would defend all fifty states against a limited ballistic missile attack originating from any point located between Libya and North Korea on the Eurasian/North African landmass.

Unfortunately, the C1 capability will be heavily dependent on the use of salvo engagement tactics. Such tactics waste resources that could be used to mount a more robust defense if more shoot-look-shoot engagements could be employed. As shown, the major weakness of the Alaska/Grand Forks NMD deployment plan is that it would require the use of salvo engagement tactics to counter any missiles launched from the Middle East or North Africa toward the densely populated East Coast of the United States. This limitation is discussed in chapter 6.

Alternative NMD Proposals

Three concepts are being discussed in Washington as alternatives or adjuncts to a land-based NMD system. The first is to either forego or supplement the planned NMD system with a boost-phase intercept capability. These ground-based systems would be deployed near potentially hostile states along the projected paths of missile trajectories targeted at the United States. The capability would be developed as a joint effort with Russia and perhaps with Ukraine. The second alternative is to base the NMD capability on navy *Aegis* cruisers. The third alternative being considered is for the United States to limit expenditures on terrestrial-based NMD capabilities and instead focus most of its effort on establishing a space-based global missile defense system as quickly as possible. Each of these proposals contains some interesting possibilities, and each also embodies limitations that must be understood. This chapter reviews each of these proposals and examines the key issues associated with each.

Boost-phase intercept



Dr. Richard Garwin, of the Council on Foreign Relations, has proposed that the United States and Russia develop and field a joint boost-phase intercept capability based on Russian soil, near Vladivostok. Such a deployment would guard against a North Korean ballistic missile attack on the United States. Dr. Garwin further postulates that if Iran develops an ICBM, the United States could also pursue a similar arrangement with Ukraine.¹ Some boost-phase intercept systems might also be deployed in defense of U.S. coastal regions to defeat ship-launched tactical missile threats that could develop. Although Garwin proposes this approach as an alternative to the land-based NMD

¹ Dr. Richard L. Garwin, "Missile Defense Policy and Arms Control Issues," briefing charts, Council on Foreign Relations, New York, August 1999. Dr. Garwin, a member of the Rumsfeld Commission, has presented this briefing in many forums. The concepts discussed in this section are based on his proposal.

program, others in the policy community are supporting a joint U.S.-Russian boost-phase intercept development effort as a capability that would supplement the planned U.S. NMD system.

Garwin points out that an Alaskan-based NMD system that intercepts incoming warheads during the midcourse phase of the trajectory will not be effective against targets such as bomblet-packaged biological agents released during the ascent phase of a trajectory. He claims midcourse hit-to-kill intercepts are susceptible to countermeasures. In addition, hostile powers can mount ballistic or cruise missiles on ships to transport the missiles closer to the U.S. coastline before launching, a more likely threat in his opinion. Since he supports the preservation of the ABM treaty, he views the development of a boost-phase intercept capability as a way of protecting the U.S. from what he considers the more likely threats without jeopardizing the ABM treaty regime.

The booster for the proposed interceptor would have to accelerate to a burnout velocity of 8.5

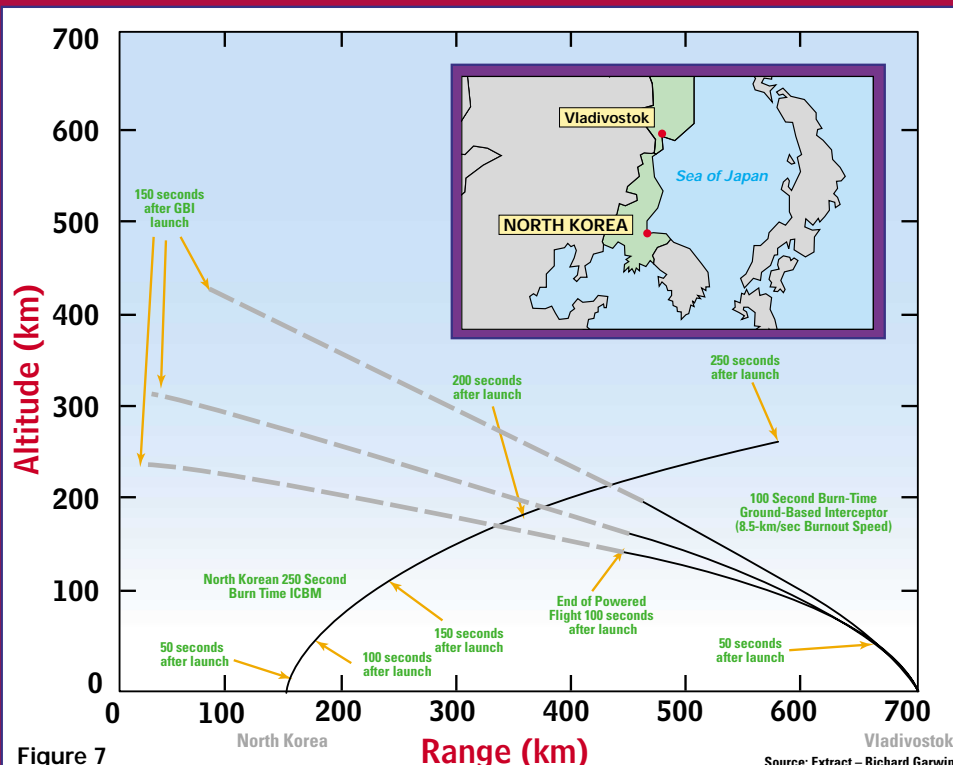
kilometers per second (kps) within 100 seconds of its launch. Its infrared sensor would focus on the flame of the boosting missile, lead the flame slightly, and ram the missile body (not the warhead). Against a slower boosting missile such as a first-generation North Korean ICBM, this system should be able to engage missiles in a semicircular area facing the oncoming missile out to distance of between 800 and 1000 kilometers.

Figure 1 shows an extract from the example launch scenario presented by Garwin to help explain this proposal. In the example, the North Korean ICBM accelerates for 250 seconds; at burnout it would be at an altitude of nearly 300 kilometers, 450 kilometers downrange from its launch point and traveling at a velocity of 7.0 kilometers per second. As previously discussed in this study, a tactical missile may burn out in 60 to 90 seconds, while more advanced solid-fueled ICBMs, such as the SS-25, burn out in about 180 seconds. The more advanced missile systems also have a faster acceleration rate and may complete burnout around 300 kilometers downrange

(as seen, for example, in the powered-flight profile of the interceptor shown in figure 1). So a boost-phase defense that is based on missile technology will vary in effectiveness and in the size of its defensive footprint, based on the type of missile it must engage.

Another limitation of a boost-phase defense, such as one sited at Vladivostok or in Ukraine, is the possibility that the intercepted missile could still be armed when it falls to earth. When the intercept occurs, the missile's acceleration will be stopped. Most likely, the missile body will be tumbling during reentry; its warhead will be short of its intended target. Because of the tumbling action, it may not be oriented correctly to protect itself from the heat of reentry,

Powered Flight Profiles of North Korean 250 Second Burn-Time ICBM and Russian-US 100 Second Burn-Time Ground-Based Interceptor



which would lead to its destruction. On the other hand, it is possible that the missile could make it to earth and still detonate.

The possibility that a missile intercepted in its boost phase could come down and detonate on the territory of the country hosting the interceptor base could prove to be an obstacle to setting up such a system. For example, Ukraine might have reservations about hitting an Iranian ICBM heading for Detroit while it is still over the Black Sea. The interception could result in the detonation of the warhead in Ukraine or elsewhere in Europe. On the other hand, the warhead might be destroyed and not detonate at all.

From a technological point of view, a boost-phase intercept system could be built. In order to do so, an IR sensor that could handle the special requirements for a boost-phase intercept would have to be developed. The major challenge for the IR focal plane is that it must be capable of detecting an IR signature at a distance and staring at the detected radiance as the distance shortens, without being overwhelmed by the increasingly intense IR energy to which it would be subjected as the interceptor closes for the kill. The problem is similar to that encountered by the human eye: we can see objects that are sunlit, but if we stare directly into the sun, the eye sensors are overwhelmed and become dazzled. For an IR sensor, getting close to the booster is equivalent to staring into the sun, much like a baseball player when trying to locate a flyball against the sun. A different type of IR sensor must be developed that can withstand intense IR energy, one that differs from those being used in the midcourse kill vehicles described in chapter 3.

For example, if the IR sensor used for the NMD system or one of the other exoatmospheric kill vehicles were deployed in a boost-phase intercept, their IR sensors would be overwhelmed by the intensity of the IR energy during the end game, and the sensor would be dazzled to the point where it would not be able to “see.” Although the technology reportedly exists to develop a sensor capable of handling a boost-phase intercept mission, that technology could not be turned into a workable sensor without some engineering devel-

opment. This is also true of the booster and other components needed for a boost-phase intercept system. More work would also be required to define the costs and time factors involved in such a deployment – if it should be decided to pursue this course of action.

Before a commitment was made to the development of a boost-phase intercept system, several policy-related issues would need to be studied, including:

- What assurance would the United States have that, in the event of crisis between the United States and the hostile country in question, the host country (for example, Russia or Ukraine) would not abruptly cancel U.S. basing rights? Since the missile defense system would most likely be needed during a crisis, this is an issue of concern.
- Would the system provide a deterrent to missile proliferation? For example, because there is a possibility that an intercepted missile could deliver its payload on the territory of the host state, would this provide some incentive for the host state to become more rigorous in fighting missile proliferation?
- Would the joint deployment of such a system likely be a confidence-building measure between the states involved, or could it prove a major point of contention in other relationships? For example, while a U.S.-Ukrainian joint deployment of a boost-phase intercept system might build confidence between those two states, it could also feed Russian paranoia that the West is moving east and invading its area of interest.
- The United States is doing very well in developing an airborne laser system that will be capable of providing an effective speed-of-light boost-phase intercept system. Would the funds needed to develop a missile-centric boost-phase intercept system further weaken or slow other missile defense procurement programs?

In short, a boost-phase intercept system has the potential for engaging selected missile systems before their payloads can be deployed. There are

clearly situations where such a system would be very valuable. However, two key questions need to be addressed: 1) Does the United State need a missile-centric boost-phase intercept program in addition to the airborne-laser development program and the space-based laser demonstration program? 2) What are the potential benefits and pitfalls of such a program in terms of interstate relations? That is, does the United States need such a program, despite its limitations, because of expected political benefits (such as a possible political benefit from a Russian-American joint development effort)?

Sea-based NMD capability

Although the technologies and programs supporting a land-based NMD system are more mature than those needed to deploy any of the alternative proposals, the January 1999 announcement of a two-year delay in the scheduled fielding of the land-based capability (from 2003 to 2005) energized the advocates of a sea-based system. In March 1999, the Heritage Foundation published a new study that made a case for a sea-based NMD system, one that could be deployed by 2004.

Supporters of a sea-based NMD system claim that such a capability would provide the United States with a mobile missile defense system that could easily be reconfigured to counter a changing missile threat environment. It has been argued that such a capability would offer two distinct advantages. First, in cases where

the *Aegis* cruiser is located along the path of the missiles' trajectory, it could intercept those missiles at an earlier point in their flight. Second, it provides greater flexibility and potentially broader coverage against missile threats around

the world.² Promoters of the *Aegis*-based NMD system postulate that such a capability can be made ready to handle the NMD mission by 2004 and that it would be able to defend the United States more effectively and at a lower cost than would a land-based system. Such a possibility warrants examination.

The United States currently plans to develop two classes of tactical missile defense systems for use on *Aegis* ships. One is the Navy Area Defense (NAD) missile defense system for defending against missiles within the earth's atmosphere (endoatmospheric). The second class is Navy Theater Wide (NTW), a system designed to intercept medium- and intermediate-range theater ballistic missiles outside of the earth's atmosphere. The central tenet of the sea-based NMD proposal is that the United States should build on the NTW program and equip each of the navy's *Aegis*-capable cruisers with ballistic missile defense systems capable of protecting the U.S. homeland.

Under the sea-based NMD proposal, all *Aegis* cruisers would be equipped with a few interceptors capable of shooting down an ICBM. The interceptors envisioned would have a burnout velocity of 4.5 kilometers per second and carry an improved light exoatmospheric projectile (LEAP) kill vehicle (a system being considered for use in the NTW missile defense system). Given the normal, global distribution of *Aegis* ships, some have suggested that none of the *Aegis* assets would need to be dedicated solely to the missile defense mission; missile defense would be treated as an additional duty.

To cover the central portion of the United States, the same type of interceptors that would be deployed on the *Aegis* platforms could also be positioned on a barge in one of the Great Lakes or, alternatively, land based at Grand Forks. The interceptors would be cued and provided with a track file from the SBIRS-Low constellation, which would need to be developed and deployed under an emergency deployment program by the end of 2004.



Figure 2

² Brian Mitchell, "Star Wars No Longer A Joke: As Threats Spread, Missile-Defense Appeal Grows," *Investor's Business Daily*, 10 September 1999, pp. A1, A22.

Many argue that since the United States has already invested \$50 billion in the *Aegis* system (figure 2), the nation should capitalize on that investment.³ With the launch tubes and trained crews already available, the *Aegis* would provide a more cost-effective solution to NMD than would a land-based system. Unfortunately, the issue is much broader than that of crews and launch cells.

A tour of *Aegis* cruiser capabilities

The navy has 22 *Aegis* cruisers equipped with the vertical-launch system (VLS) and 30 VLS-equipped destroyers (10 more *Aegis* destroyers are planned to join the fleet by 2005).⁴ Each cruiser is equipped with 122 vertical-launch cells; the destroyers each have 90. These 21-inch diameter cells are loaded with a variety of missiles that can include: *Tomahawk* land-attack cruise missiles, two types of air-defense missiles, anti-submarine missiles, and, soon, ballistic missile interceptors. Since all onboard ordinance is loaded in the launch cells, no spare missiles are present on the ships to allow for rapid reload. Although both cruisers and destroyers have the potential for performing exoatmospheric missile intercepts, current plans are to equip only selected *Aegis* cruisers for that mission since the cruisers have a more senior command and staff structure to deal with a rapid decision making process to determine whether or not to attack a missile in space (it might not be hostile).

The current capabilities of these cruisers have limitations with regard to the assignment of exoatmospheric missile defense missions to these ships:

- The *Aegis*'s phased-array SPY-1D radar is the primary target-acquisition radar for the *Aegis*'s air defense mission; its design is optimized for the performance of that role. The system reportedly screens the enormous volume of radar returns by ignoring echoes from objects beyond the 500-kilometer range (because of

computational requirements) and disregarding objects detected within its area of search that do not behave in accordance with specified parameters (that is, objects are disregarded unless they are travelling within specified velocity ranges and exhibit characteristics of a potentially interesting man-made item). Moreover, the radar operates over a narrow set of frequencies (bandwidth), a design factor that provides it with certain advantages in performing its air-defense mission, but one that also limits its complex target-array discrimination potential (discussed in chapter 3). Consequently, the addition of an exoatmospheric missile defense mission requires a major reworking and/or augmentation of the *Aegis*'s target-acquisition systems (a difficult task considering the complexity of the system's 12 million lines of computer code and the physical configuration of the system).⁵

- System designers need to acquire a better understanding of the capability of the hull and the ablative material lining the VLS launch cells to withstand the pressure and heat generated by the launch of fast interceptors having a burnout velocity above, for example, 4.5 kilometers per second. The deployment of an NMD system is not only a near-term objective, it is a requirement that will likely evolve for many years to come. As will be shown, a 4.5-kps interceptor limits the potential of the NTW system to perform the NMD mission. If a faster interceptor were needed in the future, it might require that the ships be reconfigured/rebuilt to strengthen their hulls and modify the VLS firing cells.

Under the sea-based NMD proposal, all *Aegis* cruisers would be equipped with a few interceptors capable of shooting down an ICBM. The interceptors envisioned would have a burnout velocity of 4.5 kilometers per second and carry an improved light exoatmospheric projectile (LEAP) kill vehicle...

– p. 5.4

³ The Heritage Foundation's Commission on Missile Defense, "Defending America: A Plan to Meet the Urgent Missile Threat," March 1999, 36.

⁴ Robert Holzer, "U.S. Navy Hopes to Expand Fleet," *Defense News*, 31 January 2000, p. 1.

⁵ Robert Holzer, "Pentagon Orders Dedicated NTW on Cruisers," *Defense News*, 12 July 1999, p. 3.

The navy's exoatmospheric intercept program

The current NTW program would be the starting point for development of an NMD system deployed by 2004. As it now stands, the NTW program is structured to field an integrated Block I NTW capability by 2010, with the possibility of accelerating the first-unit-equipped (FUE) date to 2008.

Although LEAP is likely to have a significant capability to make theatre missile intercepts, many in the technical community have serious reservations about its potential effectiveness against ICBM-class missiles.

– p. 5.6

The Block I system

The NTW missile defense system was first envisioned as a single system having the capabilities now ascribed to the Block II system (described later in this section). However, in response to the rapid proliferation of ballistic missiles, the administration (apparently on the basis of a navy proposal) decided to develop and deploy an interim theater missile defense capability known

as the Block I NTW program. For this initial response, 80 Block I interceptors with a burnout velocity of approximately 3 kilometers per second were planned to be deployed aboard four *Aegis* cruisers by 2005.⁶ The Block I interceptors were to be tipped with improved LEAP kill vehicles.

The rapid Block I development program has since given way to a revised plan, with development proceeding in a more measured manner. The Block I program is now structured in three parts. Block IA will provide a capability to deploy four interceptors by 2006. Block IB will equip one *Aegis* ship by 2008 to perform the NTW mission on a reconfigurable basis (the ship will be unable

to perform other missions while performing the NTW role). The Block IC element will equip the first *Aegis* cruiser in 2010 with a capability to perform multiple missions while providing NTW missile defense coverage. As noted earlier, it is possible that the Block IC capability could be accelerated to 2008.⁷

In support of the NTW program, a series of *Aegis* LEAP Intercept (ALI) tests are planned between the end of 2000 and 2002 to determine the performance capabilities of the LEAP system.⁸ "At the completion of ALI testing and based on the test results, the DoD will make a determination on the future course of the NTW program."⁹

There have long been questions regarding the capability of the LEAP system to operate effectively against advanced target sets. The LEAP kill vehicle was developed a decade ago as part of a technology demonstration program. Indeed, it pioneered the technologies that have since been developed further and incorporated into current-generation kill vehicles. One of the demonstration objectives of the LEAP program was to push the state of miniaturization technology to determine how small such a kill vehicle could be made. The resulting product is very compact and lightweight, making a small launch payload, but also one with limited target-discrimination and system-divert capabilities.

Although LEAP is likely to have a significant capability to make theater missile intercepts, many in the technical community have serious reservations about its potential effectiveness against ICBM-class missiles.¹⁰ The LEAP's IR sensor system does not have the cryogenic cooling needed to detect cold-body objects from a distance nor is its optical system as capable as the one used on the EKV. The practical result of

⁶ Ibid.

⁷ Michael C. Sirak, "BMDO Says THAAD To Be Fielded In FY-07, Navy System In FY-10 or Earlier," *Inside Missile Defense*, 9 February 2000, 1, 10; and Lieutenant General Ronald T. Kadish, in testimony on missile defense programs, House Armed Services Committee, Research & Development and Procurement Subcommittees, 16 February 2000.

⁸ Ibid.

⁹ U.S. Department of Defense Ballistic Missile Defense Organization, "Program Summary: Navy Theater Wide," *FY 2001 President's Budget Submission*, February 2000.

¹⁰ U.S. Department of Defense Ballistic Missile Defense Organization, *Summary of Report to Congress on Utility of Sea-based Assets to National Missile Defense*, 1 June 1999, 2. Conversations with a number of experts who have been involved with the system revealed that they don't doubt that LEAP could destroy an ICBM warhead; they question if it could do so consistently with a high kill probability. They believe the system is too limited to handle the ICBM penaid suites likely to be encountered.

these limitations is that LEAP's seeker has perhaps half the range capability as that used in the EKV and its IR sensor has less capability to discriminate cold-body target arrays. Lastly, the original LEAP had small maneuvering thrusters powered by a limited fuel supply which restricted its divert capabilities. Improved LEAP uses solid-fueled thruster charges that should improve the speed of LEAP's divert maneuvers, but the size of its divert envelope is still limited.

Because of the above limitations, the LEAP interceptor must be delivered in front of its intended target with fairly high precision since its target-detection range and its divert envelope are small. Against tactical targets that are slower, less sophisticated, and have less time to cool than an ICBM target array, the LEAP is expected to provide an effective theater missile defense capability. The ALI tests are designed to determine the potential for the LEAP kill vehicle to perform the missions required of the NTW system.

The LEAP should be able to detect and destroy a massive first-generation ICBM warhead with a significant IR signature. However, some doubt its potential effectiveness against more advanced target arrays that incorporate penoids. The LEAP also appears to have physical limitations restricting its future upgrade potential to handle more sophisticated threats.

Unfortunately, the NTW Block I booster is also too slow for almost all ICBM intercept situations. The long-held rule of thumb (dating from the late 1950s) is that the intercepting missile should have at least half the velocity of its target if it is to have much probability of making a successful intercept (part of the delta V equation, as discussed in chapter 3). Since the navy's Block I missile would have a burnout velocity that is less than half the velocity of an ICBM, it would not make an effective interceptor for ICBM engagements.

In order to overcome the inability of the *Aegis*'s SPY-1 radar to support the NTW Block I requirement, the exoatmospheric target array will be tracked using a high-powered discriminator (HPD, essentially THAAD's X-band phased-array radar mounted on a turntable). Under the initial plan,

the SPY-1 would be disabled when the X-band was operating, since the HPD's software cannot be integrated into the *Aegis*'s software operating code very quickly. Under the revised plan, the NTW radar requirements would be integrated into the *Aegis*'s operating program when Block IC is implemented in 2010.

The Block II system

The Block II NTW program is the subject of a joint three-year research program between the United States and Japan, with additional funding earmarked for a possible continuation of the program beyond that timeframe. Moreover, the navy was required to submit a report to the Office of the Secretary of Defense (OSD) in June 2000 laying out the status of the NTW program. This report may contain recommendations on how to proceed in the future, to include the possibility of skipping the NTW Block I program and only developing a Block II system. Until this report is made public, there will continue to be uncertainty as to the future direction of this missile defense effort. What is known is as follows:

- **The *Standard* missile that will boost the kill vehicle in the Block II NTW system has not yet been developed.** It is envisioned that the missile will have a burnout velocity of about 4.5 kilometers per second.
- **The kill vehicle for the NTW Block II interceptor will likely be a new advanced system** that will incorporate a two-color IR sensor that will be jointly developed with Japan. The advanced kill vehicle would probably be ready for development around 2010.
- **The navy is considering deploying the Block II system on 8 *Aegis* cruisers.** There has been some consideration of equipping all 22 VLS-equipped cruisers with the Block II capability if this should be deemed necessary, but this would be expensive because of the number of equipment sets involved.

What would make the *Aegis* system NMD-capable?

The capabilities and components needed for the deployment of an effective sea-based NMD capability include:

- **Freedom from ABM treaty restrictions.** The treaty clearly prohibits sea-based, space-based, or mobile national missile defenses. Before the United States can embark on the development of a sea-based NMD system, the ABM treaty would first have to be officially modified or terminated. Because it is highly unlikely that Russia would ever agree to an ABM treaty amendment which permits a sea-based NMD capability, the sea-based NMD development proposal could be implemented quickly only if the ABM treaty were abrogated. Even if the Clinton administration opted to withdraw from or abrogate the ABM treaty, there is no indication that it would support a sea-based NMD development program. Thus, a sea-based NMD program is unlikely to be proposed officially before 2001, at the earliest.
 - **Deployment of the completed SBIRS-Low constellation.** Transforming the current SBIRS-Low program into an emergency deployment priority will likely require several months of intense effort to restructure the two program-definition/risk-reduction contracts recently awarded to Astro Spectrum and TRW. The air force is expected to award an engineering and development contract for the system in 2002.¹¹ Given the bureaucratic inertia that a new administration would have to overcome in order to accelerate this program, it is assumed that an emergency deployment effort could not begin until the second half of 2001. And given the amount of effort that must still be undertaken to deploy the SBIRS-Low constellation (discussed in chapter 3), it seems highly doubtful that the constellation could be established, even under
 - **Adaptation of the exoatmospheric kill vehicle** being developed for the land-based system for use at sea. Testing and development of this kill vehicle are still required, regardless of its intended basing mode.
 - **Development and fielding of a fairly fast interceptor.** There is no doubt that a Block II interceptor that uses the EKV technology now being developed for the land-based system could intercept an ICBM on the descending portion of its midcourse trajectory (assuming that the interceptor receives a track file on the target's trajectory and has sufficient time to fly to an intercept point). It should be noted that the payload launch vehicle (PLV) currently used to boost the prototype EKV during integrated flight tests at the Kwajalein test range has a burnout velocity of 4.4 kilometers per second.¹² If a 4.5-kps Standard missile were developed for the Block II NTW program, it also would have the potential for destroying ICBMs, provided that target track files are generated and the target is at a low enough altitude for the interceptor to reach it.
- However, a senior U.S. Navy representative testified that a faster missile would probably be required [with a fly-out speed in the range of perhaps 5.5 to 6.5 kilometers per second], to provide the *Aegis* system with a stand-alone NMD capability.¹³ Since the navy does not have an NMD mission, no serious engineering effort has been undertaken to determine if a 6.5-kps interceptor could be launched from the *Aegis* platform (as currently structured) without sinking the ship.¹⁴

¹¹ "Northrop Grumman Shares SBIRS Low Program Award," PR Newswire, 23 August 1999.

¹² Keith Englander, NMD Joint Program Office, April 1999.

¹³ Rear Admiral Rodney Rempt, in testimony before the Subcommittee on Strategic Forces, Senate Armed Services Committee, 24 February 1999, stated that a faster interceptor would be needed. In a nonattribution conversation in July 1999, a navy defense contractor working on the *Aegis* program indicated that the mission might require a missile with a 5.5- to 6.5-kps fly-out velocity.

¹⁴ Nonattribution conversation with *Aegis* program personnel, July 1999.

- **A more capable radar system.** The limitations of the SPY-1 radar for the NMD mission have already been discussed at length. The proposal to accelerate the deployment of the SBIRS-Low system is an attempt to compensate for the radar problem. Although this is helpful in the short term, it does not address the problem of how to add a radar capability later to handle more advanced target arrays. If all target discrimination is based on IR, it becomes easier for offensive missile engineers to develop penairds that are optimized against IR sensors.
- **Broadband, high-capacity satellite communication links for missile warning and trajectory information** (most of the land-based systems are linked together by fiber-optic cable). New high-

capacity satellite communication links would be needed to support a sea-based NMD capability. Since this mission would likely be executed during crisis situations when communication demand is high, this requirement would demand that continually available, broadband, military communication links be established, with first priority on use being given to the missile defense mission.¹⁵

In addition, the issue of polar missile defense coverage also must be assessed carefully. If a Russian missile were to be launched accidentally, it would pass through the northern polar region. This possibility indicates that at least two *Aegis* ships would have to be maintained on station year round, one close to Canada's east coast and the

Figure 3

Aegis NMD Issues



ICBM target acquisition is a problem:

- SPY-1 radar, used for ship & local defense, ignores inputs beyond 500 kms to avoid overloading the system
- SPY-1 is a narrow-band system which cannot discriminate between objects in a target array
- SBIRS-Low or land-based radar needed for cueing/tracking

Interceptor speed is an issue:

- Block 1 missile will be a 3 kps system
- Block 2 missile — 4.5 kps
- Future NMD missions may need a faster interceptor

The kill vehicle problem:

- LEAP has limited cold-target discrimination capability
- Multi-color IR sensors needed for better target array discrimination

Positioning:

- To counter unauthorized Russian launch, NMD must be capable of intercepting polar trajectories

¹⁵ "Browne/C4I Key to Integrating NTW With NMD," Armed Forces Newswire Service, 30 September 1999.

other just south of Alaska. (Figure 3, p 5.9) As was shown in chapter 4, even with a very fast interceptor, it is difficult to defend North America from a single point, thus the use of slower interceptors

sionally need to return to home port for rest and maintenance, this requirement would create a considerable operations and maintenance burden. Considering all of the other missions *Aegis* ships perform, it is questionable that a missile defense system that would require massive modification to or replacement of the current VLS configuration would be very cost effective.

Of particular interest is the following statement made by the navy's representative for missile defense, RADM Rodney Rempt, when he was asked during Senate testimony about the potential for a sea-based NMD system:

I think what we would look at in considering a navy system, if we were asked to do that, we would build off of all that is going on in the current land-based system. We would use the same sensors, early-warning radar, fire control radar, same battle management (maybe modified to get to the ship via satellite), [and] the same EKV kill vehicle. The real differences for us are to put that in the ship system, which is fairly straightforward, and to build the missile propulsion and basic guidance to get the kill vehicle into the right spot in space. So we would follow the land-based NMD effort.¹⁶

It is clear that a significant number of obstacles must be overcome before an *Aegis*-based NMD system could be made operational. The issues discussed in the foregoing also beg the question as to how a sea-based NMD system could be developed by 2004 and at a much lower cost than a land-based system, especially considering the fact that so much of the land-based sensor, communication, and kill-vehicle systems are also needed for a sea-based option.

Where might the *Aegis* ships be located for making ICBM interceptions?

Aegis ships deploy to combat zones during conflicts. They not only provide for local air and cruise-missile defense, they also carry strike-

Persian Gulf



East Asia



Figure 4

would indicate that at least two and perhaps three defensive areas would have to be occupied at all times. Since these ships need to be refueled and replenished, and the crews and ships occa-

¹⁶ Rempt, testimony before the Subcommittee on Strategic Forces, Senate Armed Services Committee.

missile systems, such as the *Tomahawk*. Consequently, they will normally be forward deployed off an enemy's coastline during hostilities where they provide air defense and launch cruise-missile strikes ashore. In the future, they will also provide area- and theater- missile defense capabilities. If these ships are to be multi-mission assets, as proposed by those advocating the assignment of the NMD mission to *Aegis* cruisers as an additional mission, in most cases the ships will not be able to operate very far away from the area of action.

Since the range of the *Tomahawk* is about 2000 kilometers, the ships need to be located so that their cruise missiles can reach the inland targets they are assigned to strike. Likewise, the air defense mission requires the ships to be close to shore, since, given the earth's curvature, low-flying aircraft cannot be detected from great ranges. In addition, short-range missiles are fast-boost systems that fly relatively short distances to target. Consequently, if the *Aegis* ship is too far out at sea, it would be poorly positioned to deal with theater missile and air threats (such as during possible conflicts between China and Taiwan, North and South Korea, North Korea and Japan, or Iran and the UAE)(see figure 4).

In contrast, to perform an NMD mission, the *Aegis* would have to be positioned well back from the launch site. Even so, the difficulty of hitting a ballistic missile during the ascent phase of its trajectory is significantly greater than attacking it after it passes apogee.

For a better examination of the challenges facing an *Aegis* NMD system using the proposed 4.5-kps booster and the LEAP kill vehicle, we will look at a hypothetical defense of the United States against a missile launched from North Korea's east coast. An NTW Block II-capable *Aegis* cruiser is located off the east coast of North Korea. We assume that the offensive missile is liquid-fueled; at burnout, the missile will be located between 300 to 500 kilometers downrange, be at a likely altitude between 200 and 500 kilometers, and be traveling at a velocity of 6.0 to 7.2 kps--constantly gaining altitude as it travels toward apogee.

As discussed in chapter 3, missile defenders cannot accurately predict where a boosting missile will be in the future until burnout occurs. During its boost phase, the missile is turning to line up with some invisible injection point in space. It is also accelerating, but no defender can know for certain how long or to what velocity. None of the interceptors now under consideration for a mid-course NTW or NMD system are capable of hitting an ICBM-class missile during its boost phase using currently envisioned technology.

If an *Aegis* cruiser were to be positioned close to the expected burnout location of the offensive missile (for example, about 600 kilometers off the North Korean coast), and launched its interceptors while the offensive missile was still in boost phase, with the aim of destroying the payload soon after burnout, the interceptor would have to be launched nearly straight up. At the time of launch, the *Aegis* cannot know where the missile is likely to be at the end of its boost phase. Consequently, the interceptor would inevitably miss its target, since a kill vehicle does not have the necessary divert capacity to make extremely sharp turning maneuvers in space, especially when maneuvering against a much faster missile (figure 5a, p. 5.12).

Alternatively, the commander could wait to launch the interceptor after the missile's boost phase was completed and a target track file was established. Since it would likely require 50 to 100 kilometers of missile flight after burnout to complete a preliminary track file, we assume that the interceptor would be launched when the target missile is about 600 kilometers downrange. The illustrative situation shown is as follows:

- A hostile missile traveling 6.5 kilometers per second and climbing in altitude.
- The missile is at 500 kilometers altitude when the Block II interceptor is launched.
- The target missile is traveling another 100 kilometers downrange for every 15 seconds of flight.
- The interceptor would require well over an assumed 250 seconds to try to reach target altitude.

- In 250 seconds, the target missile would be at least another 1700 kilometers downrange ($600 + 1700 = 2300$) before the kill vehicle could possibly get into an intercept position (if it were able to do so).
- The target missile would be approximately 1100 kilometers altitude above the potential intercept point (see figure 5c, p. 5.11).

In this example, an *Aegis* cruiser would need to be stationed 2500 kilometers or more downrange

earth. Consequently, an *Aegis* cruiser equipped with Block II interceptors would not be able to reach the altitude of the target in figure 5c in time to intercept. A faster interceptor would be required for success.

A third option might be to locate an *Aegis* cruiser perhaps 900 to 1200 kilometers from the North Korean coast (figure 5b). If the *Aegis* launched its interceptors (perhaps salvaging two or three in a spread formation) toward North Korea while a

Ascent Engagement Geometry: 4.5 Kps Interceptor vs. 6.5 Kps ICBM

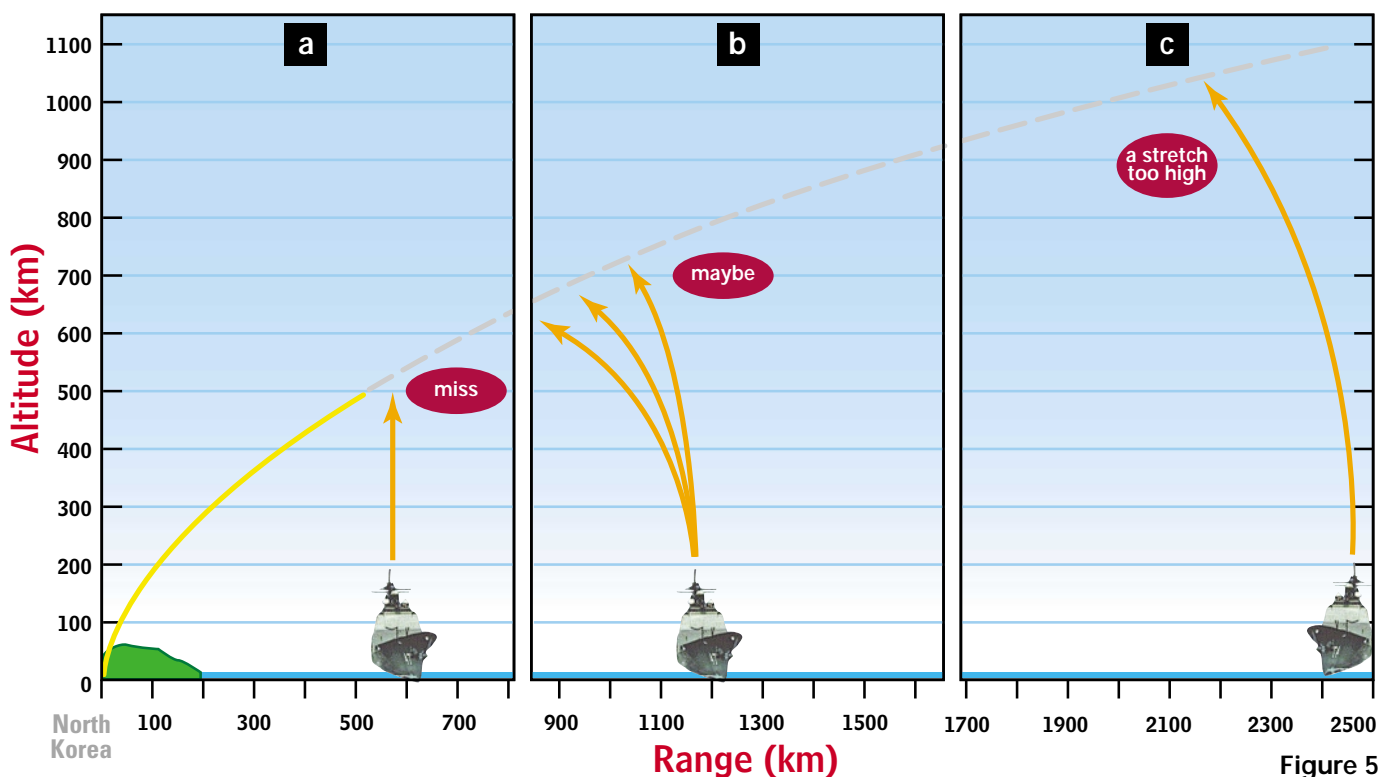


Figure 5

from the launch site to make an intercept attempt against an ICBM during the ascent phase of its trajectory (assuming it could reach 1100 kilometers altitude in 250 seconds). But gravity pulls on all objects, be they aircraft or interceptors. Because of its velocity limitations, a 4.5-kps interceptor will have a maximum ceiling estimated to be 1000-1200km when launched vertically (as would be required in this example). At maximum altitude, the interceptor will have gradually slowed to a complete stop, then fall back towards the

North Korean missile was still in its boost phase, there is some chance that one of the interceptors might be in position to divert and intercept the North Korean missile after burnout occurs. Unfortunately, there is a certain amount of guesswork in such a firing solution. In addition, the many turning maneuvers that would be required to tweak the interceptor's trajectory as the boosting missile was tracked would extract a toll--turns dump energy, slowing forward velocity.

It has also been suggested that *Aegis* cruisers could deploy into the Black Sea during a crisis and help protect the United States by destroying ICBMs during the ascent. This option has the same limitations as those presented in the North Korean examples. Figure 6 illustrates the situation that would result if a missile destined for New York City were launched from the northwest corner of Iran. The missile would approach the *Aegis* during boost phase. By the time burnout occurred, the missile would be near the ship. At burnout, the Iranian missile would be traveling at nearly 7.0 kilometers per second. An *Aegis* cruiser could not engage from this location unless given some futuristic boost-phase intercept capability. Similar limitations would apply if the target missile were too far to the east. An *Aegis* ship in the Black Sea could be used most effectively to destroy an Iranian missile launched from central Iran against the U.S. East Coast. Under some trajectory options, the missile could be within the firing solution of a 4.5-kps interceptor.¹⁷

As for terminal defenses, if an *Aegis* ship were off the coastline of Hawaii and a missile came into range while on the descending leg of its midcourse trajectory, the *Aegis* would be able to engage it if provided a track file. If, however, an unauthorized or accidentally launched missile came directly over the North Pole headed for certain portions of the continental United States, *Aegis* platforms located near the North American coasts may not be as effective as a land-based system with faster interceptors (situation dependent). Although it has been proposed that a barge loaded with interceptors be anchored in the Great Lakes to defend the central part of the nation, it is puzzling how this would be an improvement over a land-based deployment.

The *Aegis* Intercept Challenge

Figure 6



In short, it is doubtful whether the navy could long support a U.S. coastal defense deployment without petitioning Congress for more operation and maintenance funding as well as additional *Aegis* ships to replace those lost to the NMD mission. Clearly, the number of *Aegis*-capable ships required by the navy is based on an assessment of anticipated mission requirements.¹⁸ If an NMD mission requiring dedicated ships is given to the navy, the navy will certainly ask for more assets to fulfill its new obligations. Thus, the assertion that the dedicated NMD mission can be carried out with existing *Aegis* assets appears optimistic.

The space-based laser (SBL) option

The third alternative to a land-based NMD system is to accelerate the SBL technology demonstration project and transform it into a program designed to deploy an SBL constellation on an emergency

¹⁷ An *Aegis* potentially would have a longer engagement time against a missile targeted at 10,000 kilometers than it would at one aimed at 7,000 kilometers. The shorter missile ranges result in trajectories that have higher injection angles, thus gaining altitude faster. Longer-range trajectories are flatter, thus leaving the missile at a lower altitude for a longer period of time as it ascends to apogee.

¹⁸ The navy is already concerned that it has too few combat ships to support its missions. See, for example, Robert Holzer, "U.S. Navy Hopes to Expand Fleet," *Defense News*, 31 January 2000, pp. 1, 20.

Notional Space Vehicle Concept

Space Vehicle Elements

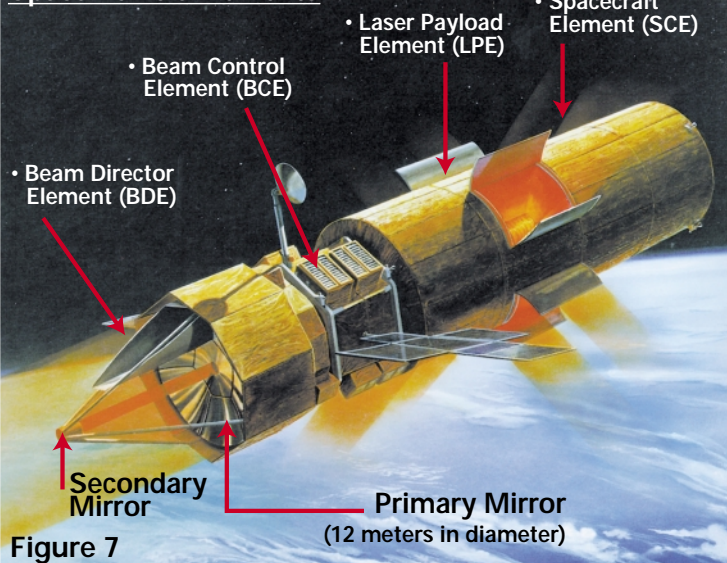


Figure 7

basis. Since an SBL system will be very expensive to develop and deploy, most supporters of this option also favor limiting expenditures on terrestrial-based NMD programs.

Without a doubt, the best place to locate a highly capable boost-phase intercept capability is in low-earth orbit (LEO). Consequently, the advocates of this option often tie this proposal to a sea-based NMD program. From this vantage point, boost-phase intercepts are possible regardless of launch location, provided that the constellation is large enough to keep interceptors continually within range of possible launch locations. By destroying the launch vehicle prior to burnout, the missile defense challenge becomes simpler when compared with the difficulty of midcourse target-array discrimination. As of now, the only space-based weapons program that the United States is pursuing is the SBL technology demonstration project.

One of the real benefits of a future SBL system would be its value as a deterrent to ballistic missile use. A laser does not have the capability of destroying a hardened, heat-shielded reentry vehicle. Instead, the laser's energy is directed against the missile's fuel. A laser engagement ruptures

the tanks and, at a minimum, interrupts the missile's acceleration before burnout. If the missile is engaged early in its boost phase, the payload could fall to earth while still over the country of launch. Countries contemplating the use of missile-delivered weapons of mass destruction would have to consider the possibility that the payload could fall within their own borders. On the other hand, if the missile were engaged near the end of its boost phase, it still might fly a ballistic trajectory, but one that would fall short of its intended target. Depending where the payload would land, it may still require subsequent engagement by ground-based defense systems.

To date, no one knows exactly what an operational space-based laser would look like. An SBL architecture study is ongoing to define a design; the study should be completed around the end of 2000. Insights from program personnel indicate that an operational SBL system would probably be built around a multi-megawatt-class, chemically powered laser that would use a segmented primary mirror approximately 12 meters (40 feet) in diameter to reflect the beam which is focused onto the primary mirror (much like a camera lens functions) by an adjustable secondary mirror (figure 7). As an alternative to placing the power sources in space, it might be possible to place only the mirrors in space and transmit energy to them from the ground. The architecture study will determine the most feasible design. Most insiders seem to believe that the energy sources will have to be based in space.

From a technological perspective, the challenges represented by an SBL system are well beyond those of any existing laser system, let alone one that will operate autonomously in space. Large lasers today require a large staff of scientists to prepare them for operations. A space-based system would have to be automated, capable of operating without routine human maintenance or physical preparation for operation. As for construction of the system, the envisioned 12-meter mirror needed for the system has never been built,¹⁹ and its construction and launch are among the major obstacles

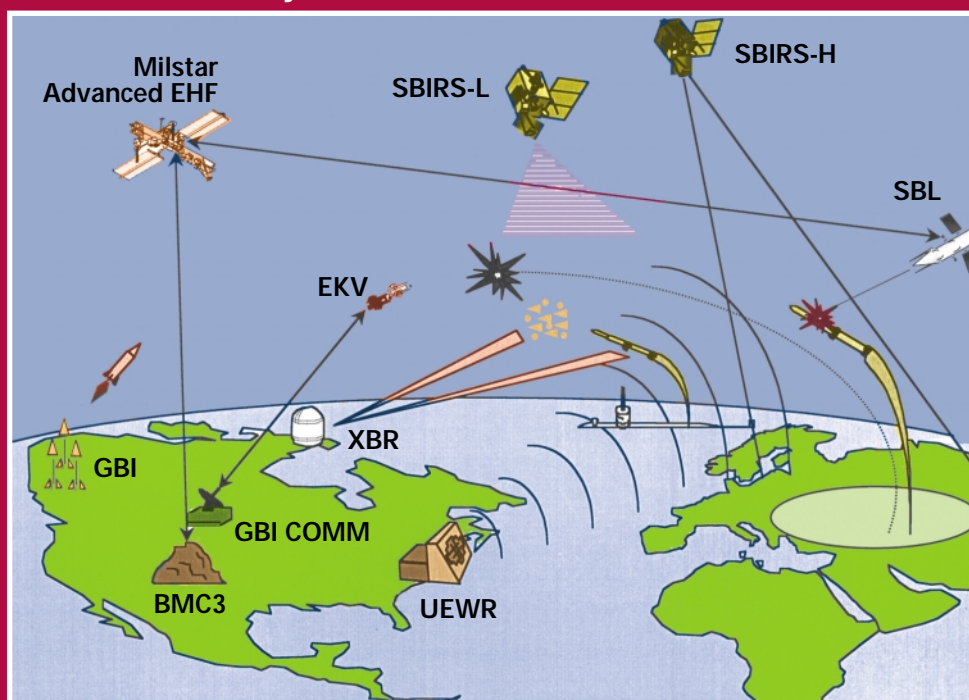
¹⁹ Colonel Doug Loverro, USAF, "Technology for Future National Missile Defense," talk given at IFPA symposium *Assessing National Missile Defense: A Roundtable Review*, Reserve Officers Association Building, Washington, D.C., 5 May 1999.

that have to be solved before an operational SBL system could be deployed.

The amount of power that the SBL will have to generate is related directly to the size of the primary mirror deployed. As in radar antenna-aperture sizing, there is an inverse correlation between the size of the mirror and the amount of power that is required to produce a directed-energy beam of a specific intensity or brightness. Consequently, a large mirror reduces the amount of brute power that the laser must generate in order to project a powerful beam. To keep the power generation requirements of the SBL at a manageable level requires the use of a very large mirror, but the deployment of such a mirror creates huge engineering problems in terms of the weight and size of the deployment package. The mirror must be capable of being collapsed for launch but, when deployed, must reflect powerful energy levels with great precision without being consumed by the energy it is focusing.

Current mirrors weigh about 90 kilograms per square meter.²⁰ To get the mirror's weight down to acceptable limits for launch into space requires that its weight be reduced to 15 to 25 kilograms per square meter. Current technology could be applied to achieve a weight of about 60 kilograms per square meter; however, further weight reduction will require some technological breakthroughs.

SBL Fits Into A Layered NMD Architecture



SBIRS-L: Space Based Infrared System Low; SBIRS-H: SBIRS High; SBL: Space-Based Laser; EHF: Extra High Frequency; EKV: Exoatmospheric Kill Vehicle; XBR: X-Band Radar; GBI: Ground-Based Interceptor; UEWR: Upgraded Early Warning Radar; BMC3: Battle Management Command, Control and Communication

Figure 8

For the operational SBL system, planners are aiming for a capability of engaging targets at ranges of over 4,000 kilometers and extending into the atmosphere as far as cloud-top level.²¹ At present, the most mature laser technology being pursued is a hydrogen-fluoride system.²² If an operational SBL could be built using current technology, the package would weigh over 70,000 pounds, constituting a bulky payload too large and too heavy to orbit using current or projected U.S. space-lift capabilities.²³ For the SBL system to be deployable its weight must be reduced to less than 50,000 pounds, and a means must be developed to lift a large mirror.

It is envisioned that once the technology is developed, an operational SBL constellation could be

²⁰ Ibid.

²¹ U.S. Department of Defense Ballistic Missile Defense Organization, "Space Based Laser: Pioneering Tomorrow's Defense," CD-ROM, undated (circa 1998); and Advanced Systems Directorate, Space and Missile Defense Center, briefing, "Understanding the Space-Based Laser Advanced Technology Demonstration Program," 5 May 1999.

²² Ibid. A gas laser is also being explored as a way to reduce weight and increase system reliability.

²³ The *Titan IV* has a lift capacity of about 40,000 pounds; the space shuttle recently deployed a 50,000-pound payload, its heaviest to date. See Rebecca Wyatt, "Photos Certify That \$1.5 Billion Telescope Works," *Washington Times*, 27 August 1999, p. A1.

deployed in a distributed pattern around the globe at an altitude of between 700 and 1100 kilometers. During the 1980s, the objective of the Strategic Defense Initiative (SDI) was to develop the capability to destroy all ballistic missiles that could attack the United States with nearly a 100 percent assurance of success. That highly demanding requirement proved too difficult to meet. The current SBL effort is aimed at being able to deploy a system, if required, that could destroy about 80 percent of the ballistic missiles launched. Thus, even with deployment of an SBL system of 20 to 40 satellites, terrestrial defenses will still be needed to handle missiles that get past the SBL shield. See figure 8, p. 5.15.

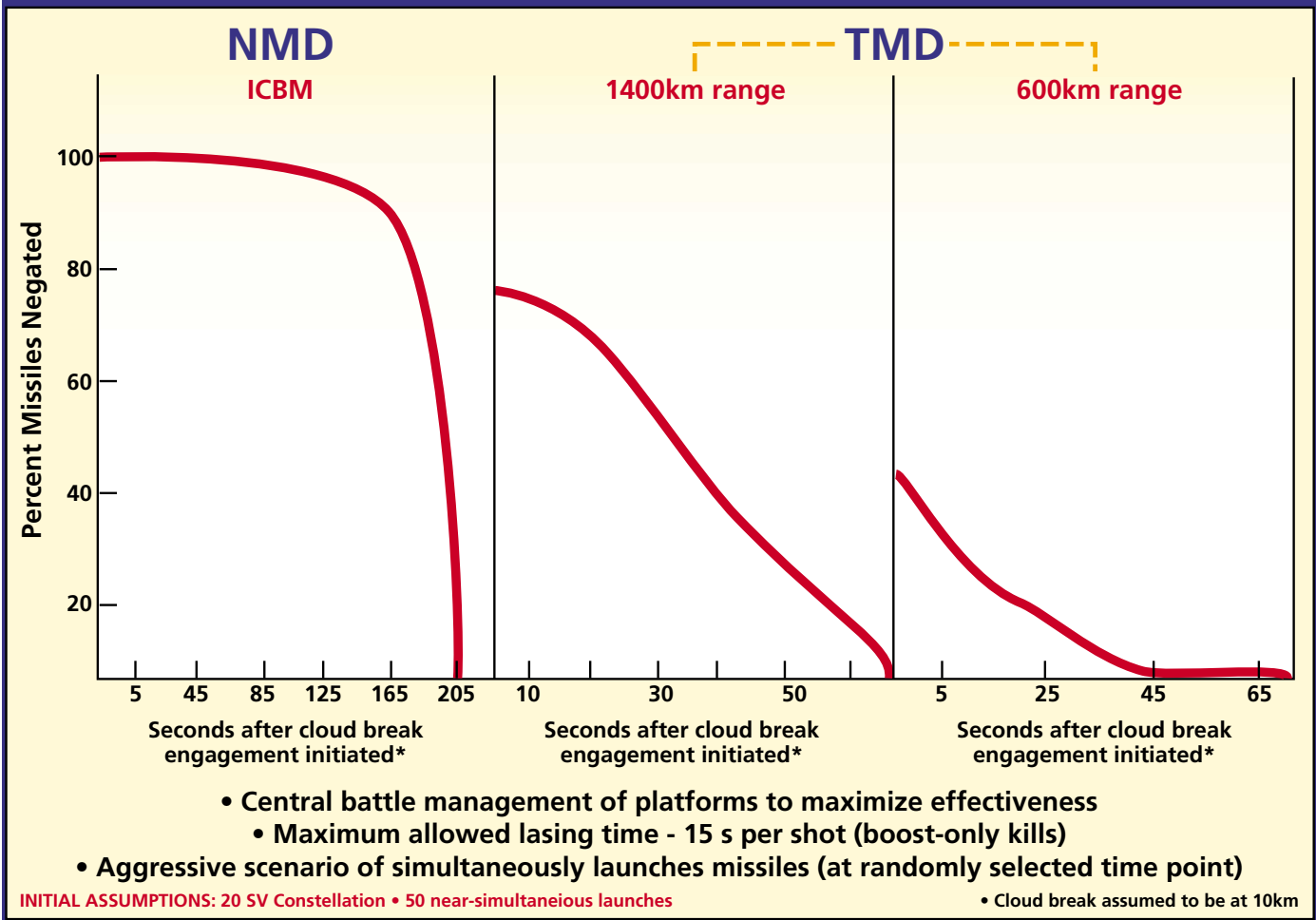
The effectiveness of a missile engagement using an SBL will be highly dependent on timely

weapons-release authority. For example, most ICBMs would need to be engaged within approximately 150 seconds of passing through the clouds if the intercept mission is to have the highest probability of success (figure 9). This would mean that U.S. Space Command would have to determine that the missile is hostile (not, for example, a Chinese astronaut) and authorize the SBL to engage it within about two minutes (preferably less) of the missile's appearance above the clouds. Considering the time required for detection and tracking, this timeline could pose a difficult command-and-control challenge for the United States.

In addition, the near-simultaneous launch of 50 or more missiles would likely overwhelm the SBL constellation.²⁴ Consequently, the mis-

BMD C2 Can Drive SBL Boost Phase Effectiveness

Figure 9



²⁴ Loverro, "Technology for Future National Missile Defense."

sile defense community envisions an eventual deployment (if so ordered) of a layered defense that includes both space and terrestrial assets.

The SBL technology demonstration program

Some of the technologies needed for SBL development are still not understood, much less developed. Consequently, the development of an SBL is viewed by the air force as a long-term project. In January 1999, the air force disclosed that it had restructured the SBL demonstration program, which now seeks to fly a technology demonstration satellite in 2012, with a possibility of accelerating the demonstration flight to 2010.

The SBL technology demonstration program aims to develop a scale model of the envisaged operational system for use in proving system technologies. If the demonstration system is launched, it is expected to use a 5-meter mirror that will be launched in a deployed state (not folded as would be required of the operational system). The model will allow the technologies required to generate and focus a long-range laser beam to be demonstrated in the hostile environment of space. Pointing, tracking, autonomous operations, handling system vibration problems, target detection, and all of the other requirements need to be demonstrated to determine if such a system is viable.

The SBL satellite has been called the most complex system the United States has ever tried to put into space.²⁵ Consequently, personnel associated with the program are quick to point out that the demonstration flight could fail, or it could work marginally well but prove that many of its incorporated technologies need a lot more work, or it could prove to work fairly well and be closer to being ready for prototype development than anticipated. In any case, deployment of a full-scale prototype and the eventual follow-on constellation are still many years away. The earliest an SBL system could be deployed is about 2018. Others, however, believe that the system could

be operational earlier if the United States managed the project as an emergency deployment requirement,²⁶ funding it at a level that would allow development to proceed more quickly.

While it is clear that a successful development and deployment of an SBL system would make a major contribution to NMD, it is also clear that the capability is still a couple of decades from being operational. At the rate that missile proliferation is occurring, the United States will be faced with a much expanded missile threat well before the SBL is ready for deployment. Moreover, like the rest of the missile defense programs, the ABM treaty is an obstacle to the eventual deployment of an SBL prototype and the resultant operational constellation.

Conclusion

Each of the systems discussed in this chapter can provide the United States with additional missile defense capabilities, and, given their feasibility, they need to be considered. However, any proposal that throws away the current program, which is well underway, to replace it with one that exists only on paper seems to risk leaving the United States with no missile defense for some years to come.

The current state of technology development argues that a naval NMD capability should be tied to the development of the current Block II NTW system, making extensive use of the technology developed for the land-based systems. With that capability, the United States would have a more capable theater asset and an option for using those ships to defend selected trajectory pathways if required to augment the land-based system during periods of crisis. On the descending leg of an ICBM trajectory, the Block II system could destroy ICBM targets within the limitations of the system to obtain a track file and deal with any penails. Targeting ICBMs on the ascent could be done in some engagement situations, but the potential for making a successful intercept would

²⁵ Ibid.

²⁶ The potential SBL testing and deployment dates were discussed by several subject matter experts at the IFPA symposium, *Assessing National Missile Defense*, 5 May 1999.

be less than an attempt made on the descending leg of the trajectory.

As for the space-based laser, this option holds real promise for an effective missile defense capability. Unfortunately, the program stagnated for much of the 1990s, and a lot of technological groundwork still needs to be accomplished before this system could be deployed. Thus, the ability to accelerate this program is limited, but should be pursued within those limits. **Clearly, directed energy systems are the way to the future. They represent the weapon systems of the twenty-first century.**



Findings and Recommendations

There has been a tendency for all great wars to be followed by a fleeting period of cooperation as the combatants seek to reestablish stability and to rebuild their economies and military forces. These periods vary in length from a few months to several years. The international system then reverts to the competitive norm when at least one or more of the major powers begin to perceive that more is lost by cooperation than might be gained through competition.

Thus it should not be surprising that the era of cooperation born in the aftermath of the Cold War is now disintegrating into the competitive model of inter-state relations. In contrast to the past decade, the future seems almost certain to be marked more by confrontation and less by cooperation among the larger powers and would-be powers. Russia, China, India, Iran, France, and an increasing number of others are unhappy with a unipolar international structure whose defining characteristic is the immense power of the United States. A growing number of states are supporting proliferation activities that are in some cases designed to help counter what is perceived as U.S. dominance or hegemony.

Among U.S. policy makers there is little agreement on how to respond to the new security environment. Some advocate the continuation of a Russo-centric security policy, with priority to be given to continuing the pursuit of bilateral arms control efforts; others simply want to build Fortress America; still others wish to be more aggressive in the use of diplomacy and economic sanctions to discourage proliferation activities in non-nuclear states.

A dispassionate review of the current situation makes it apparent that Russia and China are using

U.S. arms control desires to prevent decisive action by the U.S. on issues that might be to their detriment, while covertly assisting other states in the acquisition or the development of missile/WMD capabilities, to include probable assistance in penaid technology development. Such actions serve to undermine the larger U.S. foreign policy agenda, increase security risks to the U.S., and diffuse the focus of policy makers--thus decreasing the potential effectiveness of U.S. diplomacy.

It is time for U.S. policy makers to take a step back and reassess the situation. NMD and future arms control efforts can only be effective if they are pursued as means to a larger end, not as an end in and of themselves. An overarching strategy that reduces the incentives for states to obtain or proliferate WMD and long-range missile technologies is needed while reducing excessive U.S. and Russian strategic capabilities. Without a strategic plan, U.S. security efforts promise to be piecemeal, disjointed activities that will accomplish much less than is necessary.

Although the following findings are not inclusive, they provide a vehicle for assessing the underlying issues that mark the NMD debate. While the overall focus of this study is missile defense, the potential interaction of the NMD pro-

gram with an overall U.S. security strategy needs to be included in the assessment since NMD programs and deployment planning do not occur in a policy vacuum, but are part of a broader framework of U.S. foreign and defense policies.

Findings

Finding 1: Missile delivery systems and weapons of mass destruction are proliferating; the scope of these activities is undermining legacy arms control treaties designed to prevent proliferation. As a result, nonproliferation regimes are clearly weakening.

Proliferation activities are being fueled mainly by varying combinations of three factors:

- **A desire by potential U.S. foes for an effective counter to the United States' conventional military superiority (an asymmetrical strategy).**
- **Fear on the part of some states that they are becoming vulnerable to missile attack or blackmail. Many of these states are U.S. allies located near hostile states that possess or are acquiring missile capabilities.**
- **An apparent Russian and Chinese strategy to create new centers of power that would help counterbalance U.S. global power and to spread the attention of U.S. policy makers over a wider spectrum of challenges. Russia is clearly using the START II treaty as a means of pressuring the United States to remain a party to the ABM treaty because the deployment of a capable U.S. NMD system would thwart Russian efforts to undermine U.S. power.**

A key factor in the current proliferation movement appears to be the overwhelming military superiority of the United States. The unintended consequence of successful U.S. military actions from the *Gulf War* through the Kosovo air campaign has been to convince some states that only weapons of mass destruction can check U.S. power. At the same time, the extensive efforts that U.S. policy makers have made at times to avoid U.S. casualties have signaled potential foes that the U.S. is extremely risk averse. Consequently,

the lessons that many states have learned during the nineties is that missile-delivery systems and weapons of mass destruction provide the best means for dealing with U.S. power, since the U.S. is unlikely to risk intervention if the potential cost is very high in terms of U.S. casualties or a threat to the U.S. homeland.

Likewise, some U.S. allies are becoming concerned that if the United States becomes vulnerable to missile and WMD attack, it might not come to their aid during a crisis. As a result, there are indications that some of those allies may be seeking their own deterrent based on WMD.

Russia and China have made no secret of the fact that they are seeking to develop a multipolar world. The clear implication of such a policy is that U.S. power must be reduced and that additional centers of power must be raised. As long as Russia and China actively seek to assist the creation of a multipolar international structure, the nonproliferation arms control regimes will remain under pressure.

Finding 2: The major missile-proliferation policy challenge that the United States faces in the years ahead is to craft an international stability strategy that slows the rate of missile proliferation while continuing to reduce excessive Russian and U.S. nuclear strike capabilities. To slow the rate of missile proliferation and enhance international stability requires the formulation of a U.S. policy that incorporates at least five separate objectives:

- **Reduce the incentive for more countries to obtain long-range missile capabilities**
- **Increase costs to missile-capable countries that transfer missile technology to other states**
- **Reduce the incentive for China to increase its level of ICBM/SLBM holdings significantly**
- **Facilitate Russia's need to make further reductions in its nuclear and missile arsenal**
- **Maintain U.S. national security even in the face of crumbling nonproliferation regimes and increasing rates of international missile proliferation**

A major weakness of a Russia-centered arms control policy founded on the continuation of the ABM treaty is that it encourages other states to try to obtain long-range ballistic-missile delivery systems, since the treaty insures that the United States will not be capable of defending itself against long-range ballistic missile threats. Thus, for states seeking an asymmetrical counter to U.S. conventional military strength, the ABM treaty is an insurance policy against the possibility that the United States could negate the country's investment in an ICBM capability by fielding an effective national missile defense system. Consequently, the ABM treaty insures that third-country ICBM acquisition efforts will be rewarded.

On the other side of the missile proliferation equation, a means must be crafted to increase costs to states transferring missile technology or hardware to parties seeking new offensive missile capabilities. As discussed in this study, there are several motives for these transfers. Although the evidence is somewhat circumstantial, Russia's and China's primary motive for assisting other states to acquire missile capabilities appears to be to increase the number of potential challengers to U.S. domination of the international arena. Russia and China also seek to keep the United States party to the ABM treaty, both to maximize the value of their own deterrent force and as a means of maintaining U.S. vulnerability to the potential capabilities of the emerging missile powers.

At the same time, it is not in the interest of the United States to goad China and Russia into stepping up proliferation assistance efforts to other states or building additional missile capabilities to counter the deployment of the U.S. NMD system. Russia is clearly headed toward large reductions in its strategic missile forces due to economic pressures. As such, it is in Russia's national interest to negotiate to lock the United States into reducing its strategic capabilities to the lowest level possible, a primary Russian objective for START III. At the same time, Russia could, with major sacrifice, develop a new level of strategic weapon-delivery capabilities that would be more threatening to the United States than is now posed by Russia's missile

force. Therefore, it is not in the U.S. interest to antagonize Russia's leadership any more than necessary.

In the case of China, there are indications that Beijing is already planning to expand the size and capabilities of its future strategic nuclear force, perhaps even fielding several hundred new ICBM- and SLBM-mounted warheads by 2010 to 2015. Unfortunately, if the Chinese nuclear buildup goes too far, it could set back U.S. hopes for eliminating large numbers of strategic missile systems in the future. Thus, whatever changes the United States makes in its strategic defensive posture, it must take care not to provide Russian and Chinese policy makers with a reason for advocating that increased U.S. strategic capabilities must be answered by a military buildup of their own offensive capabilities, or the capabilities of other states in an effort to counter U.S. power.

Concurrently, U.S. policy makers must recognize that their efforts to slow missile proliferation may fail. Current foreign missile acquisition programs may well have built up too much momentum to stop. Thus, U.S. security planning must include provisions for homeland defense in a proliferated world.

Finding 3: Russia will remain the most formidable threat to the United States over the foreseeable future because of the sheer size of its nuclear arsenal compared to other potential threats. However, Russia today has nothing to gain by a deliberate nuclear attack against the United States since the U.S. counterattack would be devastating, and Russia is not capable of exploiting such a strike by seizing control of a major region such as Western Europe. Thus, in all probability, a Russian strike against the United States would take the form of one of the following:

- **An accidental or unauthorized launch of a limited number of missiles**
- **A massive missile launch based on a false warning of inbound missiles**

This new post-Cold War security situation indicates that Russia's early warning and nuclear command and control challenges should be prominent

considerations in U.S. security- and arms-control policy formulations with respect to Russia.

Under the START II treaty, Russia would have to download its MIRVed ICBM payloads to a single reentry vehicle. With nuclear command and control a key area of concern, it would be in the U.S. interest to limit the number of missiles and launch-crews fielded. Obviously, the fewer personnel involved in handling nuclear weapons, the more likely that Russia could modernize its command-and-control systems and maintain firmer control over its launch personnel. In contrast, by reducing the number of MIRVed systems deployed per START II, Russia will focus on maximizing the number of missiles and crews it has deployed in order to try to field the number of warheads allowed by the treaty, an act that would increase Russia's command-and-control difficulties.

In addition, under the provisions of START II, each party would download all but one of the reentry vehicles from the existing ICBM warhead buses. This means that if future U.S.-Russian relations sour, Russia can easily rearm its then existing missile fleet with more reentry vehicles. Even if Russia abides by the reentry vehicle limits established by the START II treaty, the deployed missiles will have a lot of unused payload capacity that could be used to carry future missile defense penetration aids.

For example, Russia's new SS-27 ICBM warhead was built to carry only one reentry vehicle in anticipation of implementation of START I (only one reentry vehicle on missiles mounted on mobile launchers) and START II (only one reentry vehicle on all ICBMs). Given the expense of building more missiles to meet its START II reentry vehicle limits, Russia would like to reconfigure the SS-27's warhead to carry three or four reentry vehicles. Obviously, under a one-reentry-vehicle configuration, the system has a lot of unused payload capacity that could be converted to carry a very robust set of penetration aids. Generally, missile engineers use less than 20 percent of a missile's payload for penaids. However, if the START II treaty comes into force, many of Russia's ICBMs will have a large amount of unused payload capacity that Russian missile engineers could configure to

carry more advanced penaids. If the capacity is used for more penaids, it will be more difficult for the U.S. NMD system to discriminate which target-array object is the actual reentry vehicle.

In light of the above considerations, it seems clear that the START II treaty as now written poses some dilemmas for U.S. policy makers. The treaty will reduce the deployed levels of strategic nuclear warheads from the 6000 authorized for each party under START I to 3000 to 3500 each. The treaty will also require Russia to stand down its heavy SS-18 ICBMs and it will also create a system configuration that is likely to maximize strain on Russia's nuclear command-and-control capabilities, be easily reversed since the missiles and buses will remain intact (easily re-uploaded to a MIRV configuration), and will facilitate the deployment of extremely challenging penaid suites because the missiles will have so much unused payload capacity. Consequently, several of the START II provisions would make a less valuable contribution to U.S. security today than was envisioned when the treaty was negotiated in 1992.

The Russian Duma voted to ratify the START II treaty on 14 April 2000, attaching conditions to the ratification that could act as a "poison pill" to U.S. agreement since the conditions would force continued U.S. adherence to the ABM treaty. Specifically, Russia's ratification specifies that U.S. failure to abide by the ABM treaty will be reason for Russia to withdraw from START II, it also specifies that the U.S. must approve the ABM treaty agreements on multilateralization and demarcation and the extension protocol to the START II treaty--signed in New York on 26 September 1997, but not yet sent to the U.S. Senate for ratification consent.

It seems likely that Russia views the current situation as having two potential benefits. First, Russia has serious reservations with several provisions of the START II treaty (discussed in Chapter 2). However, the United States was unwilling to begin talks on START III (which Russia is very interested in negotiating) until START II was ratified. Russian ratification clears the way for START III negotiation. In addition, if the poison pill (ABM issues) that the Duma included in its START II

ratification works, START II will never enter into force and the blame for failure will be placed on the United States. On the other hand, if the U.S. accepts the ABM conditions, it will ensure that the U.S. homeland remains vulnerable to future missile threats, and Russia will try to moderate its START II issues of concern in START III. President Putin claimed on 15 April that ratification of START II was part of his diplomatic offensive. Clearly, the opening shot has been fired.

The Russian conditions stipulated for START II to enter into force pose a dilemma for U.S. policy makers. Considering the issues raised above, the U.S. must consider carefully whether or not START II is still a desirable objective as currently structured and under the conditions attached to Russia's ratification.

Finding 4: China is moving toward fielding a more robust long-range strike capability. Its development of new ICBMs such as the DF-31 and DF-41 along with its efforts to develop the Type 094 ballistic-missile-launching nuclear submarine and the JL-2 SLBM, indicate that China will have a more capable long-range strike capability in the future. When these developments are examined in light of Chinese efforts to field MIRVed warheads, it is clear that China's future strategic nuclear forces will be more capable than has been seen heretofore. This more capable force could include the deployment of several hundred strategic nuclear warheads.

Unfortunately, China's evolving nuclear policy that increasingly considers nuclear weapons as warfighting tools, its rejection of arms control philosophies that advocate transparency and confidence building measures, and its military doctrine that differs from that of Western countries indicate that a stronger, more assertive, China could become a major challenge for U.S. policy makers. Obviously, the China factor must be considered by U.S. policy makers when they develop their NMD fielding plan.

A primary challenge for the United States is to facilitate the integration of a more powerful China into the international structure while limiting China's military potential to become a major threat

to U.S. security or global stability. China's push to reclaim a dominant role in regional and world affairs is bound to result in clashes between its interests and those of the United States. Such clashes are normal and should be expected as China expands its influence.

The current U.S. plan to field 100 NMD interceptors would (if the system is deployed) provide the U.S. with the capability of defeating China's current ICBM force--reported to consist of about two dozen single-warhead ICBMs. However, as China fields new MIRVed warheads and the new sea-based capabilities discussed in this study, China will still be able to penetrate the 100-interceptor U.S. missile shield planned for deployment by 2007, but only if the Chinese mount an all-out missile attack, one that would solicit an overwhelming U.S. nuclear counterstrike. Such a situation should eliminate Chinese speculation that Beijing might be able to mount a limited nuclear strike against the U.S. homeland and only receive a proportional retaliatory response.

A more interesting question develops with U.S. plans to open a second NMD interceptor site at Grand Forks, North Dakota. With the deployment of 200 interceptors with advanced capabilities split between Alaska and North Dakota, China might feel forced to build up its strike capabilities beyond the level it may now envision. Alternatively, if the second NMD site were to be situated in New England, it would not increase U.S. defense capability against China's nuclear deterrent above that fielded in Alaska, but it would substantially improve the potential effectiveness of U.S. defenses against missile threats from the Middle East and North Africa (see Chapter 4). It would also provide the United States with a second site capable of intercepting missiles originating in an arc extending from Russia through North Africa and do so using a greater proportion of shoot-look-shoot engagements than would be the case from Grand Forks.

In short, the United States should consider China's potential reaction when it determines where to locate a second NMD interceptor base. If China's response to the NMD deployments should be excessively negative, the United States could

always establish a third NMD site in Hawaii optimized to defeat China's missiles. If the threat continued to grow, a fourth site might be established at Grand Forks to defend against leakers that penetrated the three outer perimeter sites and more effort could be made to upgrade NTW interceptors to maximize their potential against ICBMs. In addition, some of the land-based interceptors could be deployed in a mobile configuration to provide flexibility for dealing with unanticipated threats, to include missiles mounted on ships.

Finding 5: A number of technologies and capabilities should be developed and system integrated for the most effective midcourse NMD intercept system possible. These capabilities include:

- **A layered system of defenses**
- **Interceptor positioning to maximize shoot-look-shoot engagement opportunities**
- **A mix of passive and active sensors based on different technological principles to complicate penetration aid development:**
 - **Multi-colored IR sensors to help discriminate target arrays**
 - **X-band and laser radar for advanced target array discrimination**
 - **Possible development of ultraviolet sensors**
- **A capability to destroy early-release submunitions (such as biological-agent-filled bombs) and/or to strip off metal-coated balloons that might conceal reentry vehicles**

While the multi-colored IR sensors deployed on unitary kill vehicles for the initial NMD system will be capable of providing a defense against a limited threat array, especially warheads carrying nuclear weapons, the final C3 NMD architecture (as currently planned with interceptor sites in Alaska and North Dakota) will still have some shortcomings that need to be addressed:

- **The planned system will not provide a layered defense.**

- **The Alaskan/North Dakota site options will have a limited shoot-look-shoot capability (heavily reliant on salvo-launch engagements for a number of threat scenarios).**
- **The interceptors will not be capable of destroying target arrays consisting of early-release submunitions such as might be used to deliver biological agents, radiological debris, or chemical agents.**
- **The system's defensive capabilities against nuclear warheads could become partially obsolete soon after fielding since the United States is not funding technology development at a level needed to insure that its NMD system is able to handle future advances in penetration aid sophistication.**

The initial NMD system likely to be fielded in Alaska should prove capable of destroying nuclear warheads accompanied by a limited penetration aid suite. The multicolored, cryogenically cooled IR sensor on its kill vehicle should be able to handle effectively target arrays of low-to-medium complexity (containing some penetration aids). Complex target arrays, however, would require a very large quantity of interceptors to destroy the target since all indiscriminated objects have to be attacked. The ability to handle more sophisticated nuclear targets and packaged biological or chemical target arrays should improve in the future as the system is upgraded to incorporate SBIRS-Low, X-band radar, laser radar, and more advanced computer processing. Most of the effort to date has been focused on optimizing the NMD system to destroy nuclear warheads.

However, unless the United States makes a serious effort to provide a response to early release submunitions (biological, radiological, and chemical) and very advanced pen aids, the NMD system could further spur the missile race rather than deter its proliferation. To leave the questions raised above unaddressed is to commit the same type of mistake that Saddam Hussein made in *Desert Storm* when he left his Western flank unprotected, a mistake made glaringly obvious by the now famous left-hook attack spearheaded by the U.S. VII Corps. Likewise, offensive missile

planners will look to exploit weaknesses in the U.S. NMD system by tailoring their warheads to take advantage of NMD vulnerabilities.

It appears that the most significant unaddressed NMD challenges that planners must still deal with are early-release submunitions and reentry vehicles with greatly altered signatures. Obviously, the potential mid-term counters to these capabilities could include submunition kill mechanisms or the potential use of *very small* nuclear-warhead kill vehicles to supplement hit-to-kill interceptors (submunition target arrays and balloon decoys could initially be neutralized at long range using a small nuclear yield, with leakers subsequently attacked with hit-to-kill interceptors). Longer term, the better solution is space-based directed-energy weapon systems that intercept the missile in the boost-phase.

In the near-to-mid term, the United States could examine the feasibility of supplementing the Airborne Laser (ABL)--which could make NMD boost-phase intercepts in situations involving favorable geography such as would be the case in a conflict on the Korean peninsula--with a limited boost-phase missile intercept capability deployed on selected *Aegis* ships. The navy's NTW program could also be optimized to augment the U.S. NMD capability for use in those situations where *Aegis* ships can be deployed at locations suitable for intercepting ICBM target arrays. These program changes could add an additional layer of defense to the NMD system. It should be clearly understood, however, that the most effective means of establishing a layered missile defense is to deploy space-based defenses augmented by terrestrial-based systems.

Finding 6: There is no alternative NMD option that can now be deployed by 2005 that could possibly provide the same level of national missile defense effectiveness as that offered by the land-based Alaskan option. Although each of the three alternative options examined in this study have some merits, they also contain some limitations which are not well understood by the policy making community:

Finding 6a: The land-based boost-phase intercept option. The proposal to establish a joint U.S.-Russian boost-phase intercept system near Vladivostok has political merit by making Russia a party to U.S. missile defense efforts, but it would not provide a capability that could replace the programmed NMD system now being developed.

The land-based boost-phase intercept system would be of limited utility since it would be effective against only North Korean ICBMs launched toward the United States. Moreover, the fact that an intercepted North Korean ICBM might fall short and detonate on Russian territory may make Russia reluctant to participate in the program. This same concern would likely arise if the system were proposed for deployment in Ukraine, Turkey, or some other country. Consequently, while the proposed system might provide a useful adjunct to U.S. NMD efforts, it is a capability with limited potential, one that could encounter significant basing resistance from proposed host-nation candidates since any intercepted warheads might well detonate on their territory (see Chapter 5).

On the other hand, the willingness of the United States to establish such a joint capability could help defuse Russian hostility toward missile defenses. As such, this proposal may have political merit. In addition, the work that would be needed to develop a sensor capable of homing-in on a missile while still in the boost phase of its trajectory would be a worthwhile endeavor. Currently, the sensors being developed for use in midcourse intercepts are not capable of making boost-phase intercepts since the brightness of the missile's plume overwhelms the sensor's ability to detect the target. The development of a boost-phase kill vehicle could provide a needed technology that could be used in other applications--such as ship-based missile defense systems.

Finding 6b: The proposed option to use the Navy Theater Wide (NTW) Block II interceptor system to replace the programmed land-based NMD system is not feasible. The NTW Block II program currently exists only on paper; the program is too immature to bet the nation's security by gambling that it could now be developed in time to deploy it by 2004 or even by 2006. In addi-

tion, the proposed *Aegis*-based NMD system has a number of inherent limitations which would result in a deployed NMD capability less robust than the planned land-based system. For example, the NTW Block II interceptor will be slower than any ICBM which will put it at a disadvantage in terms of divert velocity. The LEAP kill vehicle now available is equipped with a single-color IR sensor that is unable to discriminate cold, complex target arrays, nor can the current LEAP be upgraded in the future to handle advanced ICBM target arrays without replacing the system. Moreover, to engage ICBM-class threats will require the navy to dedicate *Aegis* assets to the NMD mission due to engagement limitation (as explained in chapter 5). As a result of these factors, an *Aegis*-based NTW capability (when deployed) should be considered as a potential NMD augmentation asset, not a replacement option for the primary land-based NMD system.

The defining requirement for an effective NMD system is not the launch platform. Rather, it is the global system of sensors and command and control assets that allow NMD interceptors to be launched and directed to an intercept point. Consequently, an *Aegis*-based NMD system would be almost completely dependent on outside assets for targeting information. Most of the programs being pursued for the land-based system will be required for an effective NMD capability, regardless of the location of the launch platform used to dispatch the interceptor.

As explained in Chapter 5, the Navy Theater Wide (NTW) Block II interceptor system clearly has the inherent potential to augment the U.S. land-based NMD system in many (but not all) threat scenarios. In cases where its potential capabilities can be brought to bear, it could contribute to the NMD system by adding an additional layer of defense. However, its current state of development is far behind that of the land-based system and the planned 4.5 kps burnout velocity for its Block II interceptor, when built, will have a more limited potential as a counter-ICBM interceptor than will the land-based system. While the U.S. needs to optimize the NTW missile defense system to counter ICBMs

where possible, the near-term planning focus should be to deploy an initial land-based NMD system while the navy focuses on developing an NTW system to counter theater-level missile threats.

The navy still faces a formidable task in upgrading its *Aegis* cruisers to handle the NTW mission. Every *Aegis* ship is unique. Its software and hardware vary from ship-to-ship since they were built over time with each ship given the latest technology available at the time of its construction. As upgrades are developed, it takes time to retrofit the entire fleet. As a result, the navy has a number of obstacles to overcome in developing its cooperative engagement program and its missile defense systems. The lack of ship standardization could result in some unforeseeable delays in deploying new capabilities on a broad scale.

As the NTW system evolves, it should have the capability built into the system to use the asset to augment the NMD system (an ABM treaty policy issue). However, the necessary hardware and software interfaces needed to upgrade its capabilities to perform ICBM intercepts within the limitations inherent in the NTW architecture should be incorporated during system development. This might include links between NTW and the SBIRS-Low sensor constellation to maximize the NTW's effectiveness to counter-ICBM target arrays.

Finding 6c: The Space-Based Laser. The SBL technology holds great promise for a highly effective future boost-phase intercept capability. Program personnel indicate that the system could not be prepared for deployment until around 2018, with other specialists claiming that the system could be made ready earlier. In assessing the conflicting claims, it appears that there is some ability to accelerate the SBL program, but since the technology involved is still very immature, it seems likely that any acceleration would only move up the deployment date by a few years rather than halving the deployment time, for example. The deployment of the SBL system will also require that the U.S. policy community address the issue of deploying weapons in space on a permanent basis.

The SBL cannot be deployed before some technological breakthroughs occur. The primary challenges are to reduce the weight of the system, to develop a primary mirror that is deployable, and to develop the technology needed to operate a megawatt-class laser autonomously in space without on-site human attending. Clearly, directed energy, speed-of-light weapon systems represent the wave of the future and should be pursued vigorously. However, the technology is still too far in the future to be viewed as a replacement for missile interceptor systems. Even if or when an SBL constellation is deployed, the terrestrial-based defense systems will still have to be maintained to provide the layered capability needed for an effective defense.

Finding 7: U.S. emphasis on the limited nature of its NMD efforts is unlikely to deter missile proliferation. If the United States is to maximize the deterrent value of its missile defense efforts, it needs to send a clear message to missile proliferators that their efforts will not prove beneficial, that the United States will take action to negate any new missile capabilities they field, to include fielding of advanced missile-defense penetration aids.

The key issues to be resolved are how to deal with ongoing missile proliferation activities and to determine the role that missile defenses should play in the resulting policy formulation. As was explained in chapters 3 and 4 of this study, the technology issues can probably be solved given time and proper program resourcing. But the issue of how to balance U.S. policy between arms control desires and missile defense requirements needs to be resolved in the near future.

It is reasonable to assume that a policy that emphasizes the limited nature of the defensive effort would not send a very strong message to those seeking to provide or gain ballistic missile capabilities. If the United States is to influence the missile acquisition decision making process, it must make it clear by both word and deed that any resources expended to develop new missile capabilities will be negated by U.S. defensive efforts.

At the same time, the United States does not want to spur nations such as China or Russia into significantly increasing their own missile capabilities or the capabilities of other states hostile to the U.S. Thus, U.S. policy needs to tie together a deterrent message against new missile capabilities with some incentives for existing missile powers to moderate their own reaction to U.S. missile defense deployment.

It should be noted that the Missile Technology Control Regime (MTCR) does not prohibit the transfer of penaid technology or components. Thus, it is legal for Russia and China to assist other countries acquire missile-defense penaid capabilities. Yet, at the same time, it should be understood that penaid technologies would present very difficult engineering challenges for emerging missile powers, even with the help of established missile experts. While it is easy to develop penaid concepts for penetrating missile defenses, it is very difficult to transform those concepts into functioning systems.

For example, advanced reentry vehicles are spin-stabilized during flight. How does one stabilize a reentry vehicle encased inside of a metal-coated balloon? Will such a warhead package deploy correctly? How does one know that the balloon will not tear or break as it is deployed with a reentry vehicle bumping around inside of it and dozens or hundreds of other objects are being deployed near it at the same time? How many flight tests are needed to work out the specifics of such challenges? Can test results be measured by the developing missile power to obtain the necessary feedback on warhead package deployment profiles?

On the other hand, would Russia or China provide pre-packaged penaid canisters to U.S. foes if the price were right? How should the United States go about deterring the transfer of penaid technology. Obviously, these types of issues must be included in U.S. NMD policy formulation.

The time for debate is running out. The U.S. policy community must "get off the fence" regarding the relationship between NMD and arms control. The current stalemate seems destined to

yield the worst of both worlds: a fig-leaf national missile defense system coupled to a proliferated world and permanent limitations on the ability of the United States to respond to new realities since bilateral Russian-U.S. arms control measures will tie the hands of future U.S. policy makers.

Recommendations

Recommendation 1: The United States should adopt a set of policies and programs designed to reduce the incentives for other states to acquire or to export missile and WMD technologies, to include those needed for penaid development. Although the details of such a program would have to be worked out through the interagency process, the policies should implement a strategy that leverages U.S. missile defense capabilities and the promise of possible future technological improvements to the system as necessary to deter long-range missile proliferation and provide a basis for greater international stability. The following example outlines such a program.

The President of the United States could make a public address along the following lines:

- **The United States will begin to deploy a national missile defense system six months from today.** We have informed Russia that the United States will no longer abide by the terms of the ABM treaty effective six months from today. Article 15 of the treaty allows each party to the treaty to withdraw with six months prior notice if extraordinary events related to the subject matter of the treaty have jeopardized that party's supreme interests. The proliferation of ballistic missile technology to new states in Eurasia is putting the United States at risk, changing the security environment that existed when we originally entered into the agreement. Therefore, we can no longer abide by the terms of the agreement negotiated with the Soviet Union, a state that no longer exists. I should note that there have been questions raised regarding the legal status of the ABM treaty. The points raised indicate that the United States could, under international law, simply declare the treaty void since the Soviet Union (the other
- treaty party) ceased to exist as a sovereign state in 1991. However, since we have treated the treaty as being legally binding for the past decade, I am providing the six months notice of our intent to deploy a national missile defense as specified by the ABM treaty.
- **Our initial national missile defense capability will be structured around 100 interceptors that are to be deployed in Alaska: another 100 interceptors will be fielded a couple of years thereafter at a site or sites still to be determined.** In addition, we are taking steps to insure that we can grow our future missile defense capabilities to whatever level required to defeat all new missile capabilities fielded from this date forward. It is our intent to take the incentive out of long-range missile proliferation efforts. We will not allow third parties to take advantage of our current vulnerability to ballistic missile attack.
- **If missile proliferation activities continue to grow, the United States will seriously consider deploying space-based missile defenses.** We do not want to deploy defenses in space, but we are unwilling to allow ourselves or our allies to be held at risk of missile attack from new threat sources.
- **For our allies, I state for the record that the United States stands ready to assist peaceful states that face a potential threat of missile attack to acquire missile defense capabilities.** If we are to deter ballistic missile proliferation, we need to reduce the potential benefits that a country might gain from obtaining missile delivery systems. Thus, we stand ready to assist other peace-loving states to obtain the means to defend themselves.
- **When the United State deploys its national missile defense system, it concurrently will reduce its deployed strategic nuclear force level by 500 warheads.** It is the intent of the United States to further reduce its nuclear forces to the START II level of 3000 to 3500 warheads as quickly as possible. *We will take steps to implement such reductions with the understanding that other states do not undertake to build up*

nuclear capabilities in an attempt to take advantage of U.S. reductions and that Russia takes steps to reduce the size of its nuclear arsenal. We will coordinate with the other nuclear states on this issue. Obviously, we can reduce our nuclear capabilities only if other nuclear powers either exercise restraint or take steps to reduce excessive nuclear capabilities.

- **I also want to make it clear that the United States will take whatever defensive action is needed to checkmate current long-range missile proliferation trends. No benefits will accrue to those parties who seek long-range missile delivery systems, be they cruise or ballistic.**

This announcement could be followed up with private consultations with Russian and Chinese leaders. They should be told that:

- **It is not the intent of the United States to negate the strategic deterrent capability Russia and China now possess.** We have lived many years under the current system of strategic capabilities. We are not trying to change that reality. However, because so much of the sensitive technologies fueling proliferation are coming from industries located on Russian and Chinese soil, *the current rate of missile proliferation can only be slowed with Russian and Chinese help. While it is not the United States' current intention to build massive missile defenses, we could be forced to do so if current proliferation rates continue unchecked. If our mutual efforts to slow the rate of proliferation are unsuccessful, we will be forced to expand our defenses to ensure our security against the new capabilities.*
- **It is not in any of our interests to enter into an arms race--it is a race the United States hopes to avoid.** Indeed, we hope to work with Russia to reduce nuclear weapon levels mutually and with China to freeze its nuclear capacities as the two major nuclear powers reduce the number of nuclear arms each state holds. The United States is well aware that our emerging defense capabilities will allow us to take slightly deeper cuts in nuclear armaments than Russia might be willing to take--we are willing to be flexible on

the details. Once we have reduced our nuclear capabilities to lower levels, we will work to negotiate a formal international agreement to stabilize the new situation.

An approach such as the one outlined above could accomplish the following:

- It would put the world on notice that the United States will not allow itself to be held at risk and that it is willing to help others obtain similar capabilities (deterrence by denial).
- It would indirectly inform Russia and China that if those countries continue to assist the proliferation efforts of other nations, their own strategic deterrence capabilities would be in danger of being neutralized. It is also clear that an arms race with the United States under current economic conditions would be punishment indeed (deterrence by threat of punishment).
- It would take away the incentive for Russia and China to build up nuclear arms or proliferate those arms as they have threatened to do if the United States withdrew from the ABM treaty. The U.S. gesture of reducing nuclear weapons in conjunction with the announcement should mute world criticism over the deployment of NMD. It would also undercut Russian or Chinese arguments that they would have to increase nuclear capabilities to balance against a more robust U.S. strategic posture. Russia and China would be on notice that an offensive arms build up would only garner more U.S. defenses.

If Russia or China began to increase their nuclear force levels, the U.S. could privately inform the state in question that it was prepared to accelerate its space-based laser program, or deploy additional defenses that would negate the additional capabilities being fielded, or some similar action.

The key to this type of approach is U.S. resolve in structuring its security policies and NMD capabilities. If rogue countries are to abandon their efforts to obtain long-range missile capabilities, they must first be convinced that there is little benefit to be gained from ballistic missile development efforts. It is also critical that the U.S. use private diplomacy in dealing with Russia and China

on the relevant bilateral issues. If a public challenge is issued, the state in question might take an adversarial course of action just to prove that the United States could not dictate its actions.

Recommendation 2: Explore the option of establishing some mobile NMD capability to counter potential ship-based missile threats or to thicken fixed-site defenses during crisis situations. For example, some number of the planned 200 or 250 land-based missile interceptors might be mounted on railcars that could be moved to vulnerable regions or projected missile-trajectory pathways during crisis situations as specific threats emerge. The NMD “missile trains” might carry a mix of long-range and short-range interceptors and on-board radar systems able to handle short- or medium-range missiles launched from ships located off the U.S. coastline as well as ICBM threats. The railcars might be moved to designated locations during crisis situations using *Amtrak* assets to minimize the sunk expense of such an option.

Other than unauthorized launch scenarios, ballistic missile forces are designed for use in coercive-diplomacy situations. Consequently, it is during international confrontations that the United States would be most at risk. Although some NMD capability would need to be kept in a constant ready-to-launch status to guard against an accidental launch, it is the crisis situations that pose the greatest threat to U.S. security. During a crisis, a mobile missile defense asset would increase uncertainty for those parties threatening to use ballistic missiles as a means of intimidating the United States.

Mobile missile defenses could increase the effectiveness of U.S. NMD assets by allowing interceptors to be positioned along likely trajectory pathways thereby increasing their kill probability (head-to-head intercepts rather than crossing trajectories) and permit greater use of shoot-look-shoot engagement tactics so that fewer interceptors would be expended per engagement. As such, a mobile-defense augmentation could significantly strengthen the effectiveness of the NMD system. Such assets might also provide an embryonic launch system that could be expanded, if necessary, to counter future cruise missile threats.

The missile trains could be manned by national guard troops, with train movement provided by *Amtrak* engines and crews. The railcars could be positioned at the fixed interceptor sites, then moved on order to one or more of a dozen or so prepared launch sites on military installations along either coastline in response to specific threat situations. The advantage this option would have over a naval alternative is that during crisis situations, the naval assets will likely be needed forward. Considering the cost of *Aegis* cruisers, the mobile option appears less expensive to maintain over time than would one requiring dedicated *Aegis* assets.

Recommendation 3: Optimize the eight *Aegis* cruisers planned for use in theater missile defense missions so as to be able to defend against ICBM threats within the inherent limitations of the NTW system. In addition, explore possible development of a ship-based boost-phase intercept system for use in situations where such a capability could be brought to bear.

The *Aegis* NTW system will have some inherent counter-ICBM capability. The eight ships likely to be equipped for the NTW mission could defend against ICBM payloads that are in the descent phase of the trajectory within the limitations imposed by the Block II's burnout velocity and the capability of its kill vehicle to discriminate cold-body objects. Because it does not appear very feasible to replace the *Aegis*' VLS system so as to permit the launch of faster interceptor missiles (above 4.5 kps), the *Aegis*' future counter-ICBM capability will likely remain limited by the velocity of the Block II interceptor.

Ideally, *Aegis* assets should operate forward during crisis situations due to the number of other missions that they perform. In cases where a threat is posed to the United States and the ICBMs (if launched) would travel over or near international waters, selected *Aegis* assets might be positioned to make an initial intercept attempt before the missile passes out of reach of the Block II interceptor. Missile trajectories such as would be flown in the case of a missile attack from North Korea to the United States, from Iran

or Iraq to the United States, or from Libya to the United States could result in the outgoing missiles traveling a course that might allow an *Aegis* cruiser to engage using Block II interceptors--if the ship can be cued by external sensors.

Although the probability of kill from ascent-phase engagements would be lower than that anticipated when the target is in the descending phase of its trajectory, early engagement attempts could thin the threat and provide the NMD battle management center with data from interceptor sensors that detail target-array characteristics. Such a capability could improve the overall effectiveness of the NMD system.

A factor that could improve the navy's capability to make an early intercept would be the development of a limited boost-phase interceptor that could be mounted when warranted on selected *Aegis* cruisers. Such a capability would force some hostile states to move their missile-launch sites back from the coastline. In some cases, this would reduce the missile's capability to reach as many U.S. targets. In other cases, it might allow NTW-capable *Aegis* ships to operate nearer the coastline of the hostile state and still be able to engage ICBMs in early midcourse since the missile launch site would be located further from the coast, thus putting the *Aegis* in a better position to attempt an interception while still handling other assigned missions such as theater missile defense (see figure 5, p. 5.12). Without a boost-phase intercept capability, some *Aegis* assets might have to be dedicated to the NMD mission and located well off the hostile coastline, out-of-range to perform likely NTW or air-defense missions. Since the ability to make the ascent interception contains a great measure of luck, such a use of *Aegis* assets may not be justifiable.

Recommendation 4: Balance the NMD development program to insure that future technology upgrades will be ready for system integration as they are needed. Priority technology development projects should include advanced software development, improved sensor technology (infrared, laser and microwave radar, and ultraviolet), faster data-processing technologies, submuni-

tion kill mechanisms, directed energy technologies, and the precursor materials and processes needed to realize the new capabilities.

As pointed out in Chapter 1, recent CIA reports point toward the likelihood of international trade in penaid technology. These reports signal that states are taking action to develop the means to defeat anticipated missile defenses. If the United States is to field an NMD system that remains capable of performing effectively, thus maximizing the deterrent value of such an effort, then the decision making community must also adequately resource the technology developments necessary to maintain or improve system effectiveness in the future.

One potential side benefit to such funding is that significant numbers of new technological discoveries would be cycled back into the U.S. economy. Although there is no way to quantify the benefit these technologies contribute, it is clear that many of the discoveries that evolved out of the SDI program of the 1980s contributed to the technologically-driven economic boom the U.S. is now enjoying. Future missile-defense technology development programs may help maintain the current momentum--it certainly would do no harm.

Recommendation 5: Develop as a priority a new policy for dealing with biological weapon systems since advances in biological engineering are facilitating the emergence of biological payloads that approach nuclear-weapon lethality levels. Consequently, the United States should adopt a new approach to defending against BW:

- **First, the United States needs to deal with the Nuclear Nonproliferation Treaty ramifications by formally equating biological weapons (BW) with nuclear weapons for purposes of nuclear retaliation. The U.S. needs to be on record that the use of those weapon systems will gain the same response as would the use of a nuclear weapon.**
- **Second, the United States should develop defenses against BW-filled early-release bomblets deployed on ballistic missiles.**

The United States needs to act vigorously to discourage biological warfare, the dark side of the biological revolution. One of the unsolved problems is how to defend against missile-delivered bomblets filled with biological agents. There have been three approaches suggested:

- First, continue to focus efforts on the development of boost-phase intercept capabilities. This capability, when available, will provide an opportunity to destroy the missile over the territory of the launching state, potentially dropping the biological agent on home ground. The space-based laser (SBL) will go far toward solving this problem, but that system will not be available for deployment for some years to come. The airborne laser destroys its target during the boost phase, but it will be location-dependent and therefore could not be relied upon to provide a consistent solution for ICBM challenges. Thus, an augmentation capability is required.
- Second, develop small inexpensive multiple-kill mechanism defenses. For several years, the U.S. pursued a technology development program called SWARM (no acronym). Unfortunately, funding for the submunition kill vehicles waxed and waned over the years. It now appears that the concept is once again in favor and its funding is being requested under a new program title called the Midcourse Multiple Kill Vehicle (MMKV) for TMD and NMD applications. Under the MMKV concept, it is envisioned that an interceptor would carry over 100 subsystems into the path of a target array where they would be deployed to independently target and ram objects with signatures that fall within specified parameters. The energy released by the impact would kill the biological organisms encased in bomblets.
- Third, develop small, highly energetic nuclear warheads that would detonate within the target-array complex. Although there is no blast effect in space (no atmosphere to compress into a blast wave), the radiation effects from a large-class warhead disrupt sensor systems, pump radiation levels in the Van Allen belt (destructive to commercial satellites), and gen-

erate a large electromagnetic pulse (EMP) that can destroy critical electronic components on earth and in space. At the same time, the radiation destroys biological agents. With the pinpoint accuracy that can now be used to target nuclear warheads, biological agents could be destroyed using a 2-kt or less boosted nuclear device. The amount of radiation boosting to the Van Allen belt would be negligible, and the EMP effects would be too small to inflict any damage. It could create minor disruptions for sensors trying to “see” follow-on systems behind the point of interception. Consequently, a small nuclear interceptor might be best employed as an initial response system to make a long-range intercept attempt that could strip penails and destroy a significant proportion of a target array, to be followed by an interceptor carrying a MMKV payload to destroy leakers.

Regardless of what type of kill mechanism is adopted (to include the possible combination of both options), the United States must find a way to take the incentive out of the development of early release submunition systems, especially those carrying biological agents. Toward this end, both the MMKV and the nuclear option should be researched for possible development as part of an overall U.S. security strategy designed both to counter and deter WMD development, deployment, and use in the challenging security environment of the 21st Century.

Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems

Signed at Moscow May 26, 1972
Ratification advised by U.S. Senate August 3, 1972
Ratified by U.S. President September 30, 1972
Proclaimed by U.S. President October 3, 1972
Instruments of ratification exchanged October 3, 1972
Entered into force October 3, 1972

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties, Proceeding from the premise that nuclear war would have devastating consequences for all mankind, Considering that effective measures to limit anti-ballistic missile systems would be a substantial factor in curbing the race in strategic offensive arms and would lead to a decrease in the risk of outbreak of war involving nuclear weapons, Proceeding from the premise that the limitation of anti-ballistic missile systems, as well as certain agreed measures with respect to the limitation of strategic offensive arms, would contribute to the creation of more favorable conditions for further negotiations on limiting strategic arms, Mindful of their obligations under Article VI of the Treaty on the Non-Proliferation of Nuclear Weapons, Declaring their intention to achieve at the earliest possible date the cessation of the nuclear arms race and to take effective measures toward reductions in strategic arms, nuclear disarmament, and general and complete disarmament, Desiring to contribute to the relaxation of international tension and the strengthening of trust between States,

Have agreed as follows:

Article I

1. Each party undertakes to limit anti-ballistic missile (ABM) systems and to adopt other measures in accordance with the provisions of this Treaty.
2. Each Party undertakes not to deploy ABM systems for a defense of the territory of its country and not to provide a base for such a defense, and not to deploy ABM systems for defense of an individual region except as provided for in Article III of this Treaty.

Article II

1. For the purpose of this Treaty an ABM system is a system to counter strategic ballistic missiles or their elements in flight trajectory, currently consisting of:
 - (a) ABM interceptor missiles, which are interceptor missiles constructed and deployed for an ABM role, or of a type tested in an ABM mode;
 - (b) ABM launchers, which are launchers constructed and deployed for launching ABM interceptor missiles; and
 - (c) ABM radars, which are radars constructed and deployed for an ABM role, or of a type tested in an ABM mode.
2. The ABM system components listed in paragraph 1 of this Article include those which are:
 - (a) operational;
 - (b) under construction;
 - (c) undergoing testing;
 - (d) undergoing overhaul, repair or conversion; or
 - (e) mothballed.

Article III

Each Party undertakes not to deploy ABM systems or their components except that:

- (a) within one ABM system deployment area having a radius of one hundred and fifty kilometers and centered on the Party's national capital, a Party may deploy: (1) no more than one hundred ABM launchers and no more than one hundred ABM interceptor missiles at launch sites, and (2) ABM radars within no more than six ABM radar complexes, the area of each complex being circular and having a diameter of no more than three kilometers; and
- (b) within one ABM system deployment area having a radius of one hundred and fifty kilometers and containing ICBM silo launchers, a Party may deploy: (1) no more than one hundred ABM launchers and no more than one hundred ABM interceptor missiles at launch sites, (2) two large phased-array ABM radars comparable in potential to corresponding ABM radars operational or under construction on the date of signature of the Treaty in an ABM system deployment area containing ICBM silo launchers, and (3) no more than eighteen ABM radars each having a potential less than the potential of the smaller of the above-mentioned two large phased-array ABM radars.

Article IV

The limitations provided for in Article III shall not apply to ABM systems or their components used for development or testing, and located within current or additionally agreed test ranges. Each Party may have no more than a total of fifteen ABM launchers at test ranges.

Article V

- 1. Each Party undertakes not to develop, test, or deploy ABM systems or components which are sea-based, air-based, space-based, or mobile land-based.
- 2. Each Party undertakes not to develop, test, or deploy ABM launchers for launching more than one ABM interceptor missile at a time from each launcher, not to modify deployed launchers to provide them with such a capacity, not to develop, test, or deploy automatic or semi-automatic or other similar systems for rapid reload of ABM launchers.

Article VI

To enhance assurance of the effectiveness of the limitations on ABM systems and their components provided by the Treaty, each Party undertakes:

- (a) 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; and
- (b) not to deploy in the future radars for early warning of strategic ballistic missile attack except at locations along the periphery of its national territory and oriented outward.

Article VII

Subject to the provision of this Treaty, modernization and replacement of ABM systems or their components may be carried out.

Article VIII

ABM systems or their components in excess of the numbers or outside the areas specified in this Treaty, as well as ABM systems or their components prohibited by this Treaty, shall be destroyed or dismantled under agreed procedures within the shortest possible agreed period of time.

Article IX

To assure the viability and effectiveness of this Treaty, each Party undertakes not to transfer to other States, and not to deploy outside its national territory, ABM systems or their components limited by this Treaty.

Article X

Each Party undertakes not to assume any international obligations which would conflict with this Treaty.

Article XI

The Parties undertake to continue active negotiations for limitations on strategic offensive arms.

Article XII

1. For the purpose of providing assurance of compliance with the provisions of this Treaty, each Party shall use national technical means of verification at its disposal in a manner consistent with generally recognized principles of international law.
2. Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with paragraph 1 of this Article.
3. Each Party undertakes not to use deliberate concealment measures which impede verification by national technical means of compliance with the provisions of this Treaty. This obligation shall not require changes in current construction, assembly, conversion, or overhaul practices.

Article XIII

1. To promote the objectives and implementation of the provisions of this Treaty, the Parties shall establish promptly a Standing Consultative Commission, within the framework of which they will:

- (a) consider questions concerning compliance with the obligations assumed and related situations which may be considered ambiguous;
- (b) provide on a voluntary basis such information as either Party considers necessary to assure confidence in compliance with the obligations assumed;
- (c) consider questions involving unintended interference with national technical means of verification;
- (d) consider possible changes in the strategic situation which have a bearing on the provisions of this Treaty;
- (e) agree upon procedures and dates for destruction or dismantling of ABM systems or their components in cases provided for by the provisions of this Treaty;
- (f) consider, as appropriate, possible proposals for further increasing the viability of this Treaty; including proposals for amendments in accordance with the provisions of this Treaty;
- (g) consider, as appropriate, proposals for further measures aimed at limiting strategic arms.

2. The Parties through consultation shall establish, and may amend as appropriate, Regulations for the Standing Consultative Commission governing procedures, composition and other relevant matters.

Article XIV

1. Each Party may propose amendments to this Treaty. Agreed amendments shall enter into force in accordance with the procedures governing the entry into force of this Treaty.
2. Five years after entry into force of this Treaty, and at five-year intervals thereafter, the Parties shall together conduct a review of this Treaty.

Article XV

1. This Treaty shall be of unlimited duration.
2. Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests. It shall give notice of its decision to the other Party six months prior to withdrawal from the Treaty. Such notice shall include a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests.

Article XVI

1. This Treaty shall be subject to ratification in accordance with the constitutional procedures of each Party. The Treaty shall enter into force on the day of the exchange of instruments of ratification.
2. This Treaty shall be registered pursuant to Article 102 of the Charter of the United Nations.

DONE at Moscow on May 26, 1972, in two copies, each in the English and Russian languages, both texts being equally authentic.

Protocol to the Treaty Between the United States of America And the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems

Signed at Moscow July 3, 1974
Ratification advised by U.S. Senate November 10, 1975
Ratified by U.S. President March 19, 1976
Instruments of ratification exchanged May 24, 1976
Proclaimed by U.S. President July 6, 1976
Entered into force May 24, 1976

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties, Proceeding from the Basic Principles of Relations between the United States of America and the Union of Soviet Socialist Republics signed on May 29, 1972, Desiring to further the objectives of the Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems signed on May 26, 1972, hereinafter referred to as the Treaty, Reaffirming their conviction that the adoption of further measures for the limitation of strategic arms would contribute to strengthening international peace and security, Proceeding from the premise that further limitation of anti-ballistic missile systems will create more favorable conditions for the completion of work on a permanent agreement on more complete measures for the limitation of strategic offensive arms,

Have agreed as follows:

Article I

1. Each Party shall be limited at any one time to a single area out of the two provided in Article III of the Treaty for deployment of anti-ballistic missile (ABM) systems or their components and accordingly shall not exercise its right to deploy an ABM system or its components in the second of the two ABM system deployment areas permitted by Article III of the Treaty, except as an exchange of one permitted area for the other in accordance with Article II of this Protocol.
2. Accordingly, except as permitted by Article II of this Protocol: the United States of America shall not deploy an ABM system or its components in the area centered on its capital, as permitted by Article III(a) of the Treaty, and the Soviet Union shall not deploy an ABM system or its components in the deployment area of intercontinental ballistic missile (ICBM) silo launchers as permitted by Article III(b) of the Treaty.

Article II

1. Each Party shall have the right to dismantle or destroy its ABM system and the components thereof in the area where they are presently deployed and to deploy an ABM system or its components in the alternative area permitted by Article III of the Treaty, provided that prior to initiation of construction, notification is given in accord with the procedure agreed to in the Standing Consultative Commission, during the year beginning October 3, 1977 and ending October 2, 1978, or during any year which commences at five year intervals thereafter, those being the years of periodic review of the Treaty, as provided in Article XIV of the Treaty. This right may be exercised only once.
2. Accordingly, in the event of such notice, the United States would have the right to dismantle or destroy the ABM system and its components in the deployment area of ICBM silo launchers and to deploy an ABM system or its components in an area centered on its capital, as permitted by Article III(a) of the Treaty, and the Soviet Union would have the right to dismantle or destroy the ABM system and its components in the area centered on its capital and to deploy an ABM system or its components in an area containing ICBM silo launchers, as permitted by Article III(b) of the Treaty.

Appendix A

3. Dismantling or destruction and deployment of ABM systems or their components and the notification thereof shall be carried out in accordance with Article VIII of the ABM Treaty and procedures agreed to in the Standing Consultative Commission.

Article III

The rights and obligations established by the Treaty remain in force and shall be compiled with by the Parties except to the extent modified by this Protocol. In particular, the deployment of an ABM system or its components within the area selected shall remain limited by the levels and other requirements established by the Treaty.

Article IV

This Protocol shall be subject to ratification in accordance with the constitutional procedures of each Party. It shall enter into force on the day of the exchange of instruments of ratification and shall thereafter be considered an integral part of the Treaty.

DONE at Moscow on July 3, 1974, in duplicate, in the English and Russian languages, both texts being equally authentic.

FOR THE
UNITED STATES
OF AMERICA

RICHARD NIXON

*President of the
United States of America*

FOR THE UNION OF
SOVIET SOCIALIST
REPUBLICS

L.I. BREZHNEV

*General Secretary of the Central
Committee of the CPSU*

Agreed Statements, Common Understandings, and Unilateral Statements Regarding the Interim Agreement Between the United States of America and the Union of Soviet Socialist Republics On Certain Measures with Respect to the Limitation of Strategic Offensive Arms

1. Agreed Statements

The document set for the below was agreed upon and initiated by the Heads of the Delegations on May 26, 1972 (letter designations added):

AGREED STATEMENTS REGARDING THE INTERIM AGREEMENT BETWEEN THE UNITED STATES OF AMERICA AND THE UNION OF SOVIET SOCIALIST REPUBLICS ON CERTAIN MEASURES WITH RESPECT TO THE LIMITATION OF STRATEGIC OFFENSIVE ARMS

[A]

The Parties understand that land-based ICBM launchers referred to in the Interim Agreement are understood to be launchers for strategic ballistic missiles capable of ranges in excess of the shortest distance between the northeastern border of the continental U.S. and the northwestern border of the continental USSR.

[B]

The Parties understand that fixed land-based ICBM launchers under active construction as of the date of signature of the Interim Agreement may be completed.

[C]

The Parties understand that in the process of modernization and replacement the dimensions of land-based ICBM silo launchers will not be significantly increased.

[D]

The Parties understand that during the period of the Interim Agreement there shall be no significant increase in the number of ICBM or SLBM test and training launchers, or in the number of such launchers for modern land-based heavy ICBMs. The Parties further understand that construction or conversion of ICBM launchers at test ranges shall be undertaken only for purposes of testing and training.

[E]

The Parties understand that dismantling or destruction of ICBM launchers of older types deployed prior to 1964 and ballistic missile launchers on older submarines being replaced by new SLBM launchers on modern submarines will be initiated at the time of the beginning of sea trials of a replacement submarine, and will be completed in the shortest possible agreed period of time. Such dismantling or destruction, and timely notification thereof, will be accomplished under procedures to be agreed upon in the Standing Consultative Commission.

2. Common Understandings

Common understandings of the Parties on the following matters was reached during the negotiations:

A. Increase in ICBM Silo Dimensions

Ambassador Smith made the following statement on May 26, 1972:

The Parties agree that the term "significantly increased" means that an increase will not be greater than 10-15 percent of the present dimensions of land-based ICBM silo launchers.

Minister Semenov replied that this statement corresponded to the Soviet understanding.

B. Standing Consultative Commission

Ambassador Smith made the following statement on May 22, 1972:

The United States proposes that the sides agree that, with regard to initial implementation of the ABM Treaty's Article XIII on the Standing Consultative Commission (SCC) and of the consultation Articles to the Interim Agreement

Appendix A

on offensive arms and the Accidents Agreement, agreement establishing the SCC will be worked out early in the follow-on SALT negotiation; until that is completed, the following arrangements will prevail: when SALT is in session, any consultation desired by either side under these Articles can be carried out by the two SALT Delegations; when SALT is not in session, ad hoc arrangements for any desired consultations under these Articles may be made through diplomatic channels.

Minister Semenov replied that, on an ad referendum basis, he could agree that the U.S. statement corresponded to the Soviet understanding.

C. Standstill

On May 6, 1972, Minister Semenov made the following statement:

In an effort to accommodate the wishes of the U.S. side, the Soviet Delegation is prepared to proceed on the basis that the two sides will in fact observe the obligations of both the Interim Agreement and the ABM Treaty beginning from the date of signature of these two documents.

In reply, the U.S. Delegation made the following statement on May 20, 1972:

The U.S. agrees in principle with the Soviet statement made on May 6 concerning observance of obligations beginning from date of signature but we would like to make clear our understanding that this means that, pending ratification and acceptance, neither side would take any action prohibited by the agreements after they had entered into force. This understanding would continue to apply in the absence of notification by either signatory of its intention not to proceed with ratification or approval.

The Soviet Delegation indicated agreement with the U.S. statement.

3. Unilateral Statements

(a) The following noteworthy unilateral statements were made during the negotiations by the United States Delegation.

A. Withdrawal from the ABM Treaty

On May 9, 1972, Ambassador Smith made the following statement:

The U.S. Delegation has stressed the importance the U.S. Government attaches to achieving agreement on more complete limitations on strategic offensive arms, following agreement on an ABM Treaty and on an Interim Agreement on certain measures with respect to the limitation of strategic offensive arms. The U.S. Delegation believes that an objective of the follow-on negotiations should be to constrain and reduce on a long-term basis threats to the survivability of our respective strategic retaliatory forces. The USSR Delegation has also indicated that the objectives of SALT would remain unfulfilled without the achievement of an agreement providing for more complete limitations on strategic offensive arms. Both sides recognize that the initial agreements would be steps toward the achievement of more complete limitations on strategic arms. If an agreement providing for more complete strategic offensive arms limitations were not achieved within five years, U.S. supreme interests could be jeopardized. Should that occur, it would constitute a basis for withdrawal from the ABM Treaty. The U.S. does not wish to see such a situation occur, nor do we believe that the USSR does. It is because we wish to prevent such a situation that we emphasize the importance the U.S. Government attaches to achievement of more complete limitations on strategic offensive arms. The U.S. Executive will inform the Congress, in connection with Congressional consideration of the ABM Treaty and the Interim Agreement, of this statement of the U.S. position.

B. Land-Mobile ICBM Launchers

The U.S. Delegation made the following statement on May 20, 1972:

I wish to emphasize the importance that the United States attaches to the provisions of Article V, including in particular their application to fitting out or berthing submarines.

C. Covered Facilities

The U.S. Delegation made the following statement on May 20, 1972:

I wish to emphasize the importance that the United States attaches to the provisions of Article V, including in particular their application to fitting out or berthing submarines.

Appendix A

D. "Heavy" ICBM's

The U.S. Delegation made the following statement on May 26, 1972:

The U.S. Delegation regrets that the Soviet Delegation has not been willing to agree on a common definition of a heavy missile. Under these circumstances, the U.S. Delegation believes it necessary to state the following: The United States would consider any ICBM having a volume significantly greater than that of the largest light ICBM now operational on either side to be a heavy ICBM. The U.S. proceeds on the premise that the Soviet side will give due account to this consideration.

b) The following noteworthy unilateral statement was made by the Delegation of the U.S.S.R. and is shown here with the U.S. reply:

Taking into account that modern ballistic missile submarines are presently in the possession of not only the U.S., but also of its NATO allies, the Soviet Union agrees that for the period of effectiveness of the Interim 'Freeze' Agreement the U.S. and its NATO allies have up to 50 such submarines with a total of up to 800 ballistic missile launchers thereon (including 41 U.S. submarines with 656 ballistic missile launchers). However, if during the period of effectiveness of the Agreement U.S. allies in NATO should increase the number of their modern submarines to exceed the numbers of submarines they would have operational or under construction on the date of signature of the Agreement, the Soviet Union will have the right to a corresponding increase in the number of its submarines. In the opinion of the Soviet side, the solution of the question of modern ballistic missile submarines provided for in the Interim Agreement only partially compensates for the strategic imbalance in the deployment of the nuclear-powered missile submarines of the USSR and the U.S. Therefore, the Soviet side believes that this whole question, and above all the question of liquidating the American missile submarine bases outside the U.S., will be appropriately resolved in the course of follow-on negotiations.

On May 24, Ambassador Smith made the following reply to Minister Semenov:

The United States side has studied the "statement made by the Soviet side" of May 17 concerning compensation for submarine basing and SLBM submarines belonging to third countries. The United States does not accept the validity of the considerations in that statement.

On May 26 Minister Semenov repeated the unilateral statement made on May 17. Ambassador Smith also repeated the U.S. rejection on May 26.

See Article 7 of Agreement to Reduce the Risk of Outbreak of Nuclear War Between the United States of America and the Union of Soviet Socialist Republics, signed Sept. 30, 1971.

**FOR THE
UNITED STATES
OF AMERICA**

RICHARD NIXON

*President of the
United States of America*

**FOR THE UNION OF
SOVIET SOCIALIST
REPUBLICS**

L.I. BREZHNEV

*General Secretary of the Central
Committee of the CPSU*

The Evolution of National Missile Defense Policy

The primary constraint to the development of an effective NMD system is the 1972 Anti-Ballistic Missile (ABM) Treaty (as amended by its 1974 Protocol). This treaty prohibits the establishment of a national missile defense, limits the number of defense systems to 100 interceptors located at a single deployment area (either the nation's capital or a designated ICBM silo-launch field), prohibits sea-based, air-based, or space-based anti-ballistic missile defenses, and contains limitations on radars and other related ABM issues. The United States designated Grand Forks, North Dakota (ND), as its ICBM silo-launch field to be defended, while the Soviet Union designated its capital city, Moscow (figure 1).

The United States subsequently built and then immediately closed the Safeguard missile-defense base at Grand Forks, while Russia still operates nearly 100 nuclear-tipped defensive missiles around Moscow: most are 350-km exoatmospheric missiles, the *Gorgon*;¹ the remainder are 80-km endoatmospheric missiles, the *Gazelle*. These two interceptor systems are deployed at firing sites double-ringing Moscow at roughly 60 and 110 kms; both missile systems are controlled by the Pill Box phased-array radar located just north-northeast of Moscow at Pushkino. During the last few years, the Moscow ABM system has deteriorated and is currently reported to be in a poor state of readiness as Russia has not been

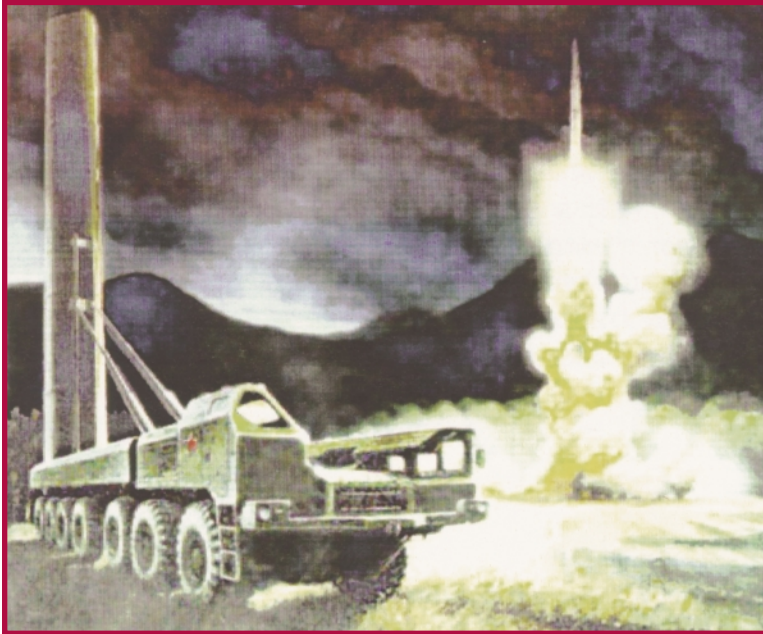


Figure 1

¹ "Strategic Ballistic Missile Defense," *The Arms Control Reporter*, July 1993, p. 575.E.O.2. The *Gorgon* is a large missile similar in size to the U.S. *Minuteman III* (conversation with Steven J. Zaloga, January 1998). With advanced targeting and fly-out control, there is no physical reason why this nuclear-armed missile could not make intercepts at distances well beyond its reported 350-km range. The designer of the system claims they can make intercepts 2.5 to 3 times further than the systems are certified to handle. See Sergey Goryainov, "Interview With Anatoliy Georgiyevich Bastistov, General Designer of the A-135 Moscow ABM System," *Moscow Itogi*, May 20, 1997, translated in FBIS-SOV-97-232, 20 August 1997.

able to fund adequately its operation and maintenance expenses.²

The U.S. attitude toward missile defenses began changing during the Reagan administration. In



The Strategic Defense Initiative (SDI) was heavily focused on the development of space-based missile defense systems designed to destroy offensive missile systems during the boost phase of the trajectory when a missile is at its most vulnerable. If a missile can be killed prior to payload deployment, the daunting challenge of midcourse target discrimination and the possible deployment of multiple reentry vehicles can be avoided.

However, during the early 1990s, the space-based elements of the SDI program ran into difficulty. First, it became evident that directed energy weapon systems, capable of engaging ballistic missile systems at the speed of light, could not be developed at a feasible cost for deployment during the near to mid-term. In short, the directed-energy technologies still had too many hurdles to cross before they could be deployed as part of a space-based missile defense system.

Second, the use of space-based interceptor systems which relied on missile technology, such as *Brilliant Pebbles*, were also shown to have limitations. Under this concept, a couple of different basing options were explored for various space-based missile interceptor systems. For example, one used a “parking garage” concept with the sensor systems attached to the garage, thus allowing the use of inexpensive interceptors to attack ascending missiles during boost phase. This basing method was judged vulnerable to anti-satellite (ASAT) capabilities.

Another system dispersed the missile interceptors, but required more costly sensors on each missile system. In addition, there were questions regarding the potential effectiveness of such systems. Missiles travel at relatively slow speeds in comparison to the speed of light. While the missile interceptors were judged capable of catching the slow-boosting, liquid-fueled Russian SS-18s during the boost phase, it was questionable if the space-based missiles under consideration could intercept a fast-burning, solid-fueled system (such

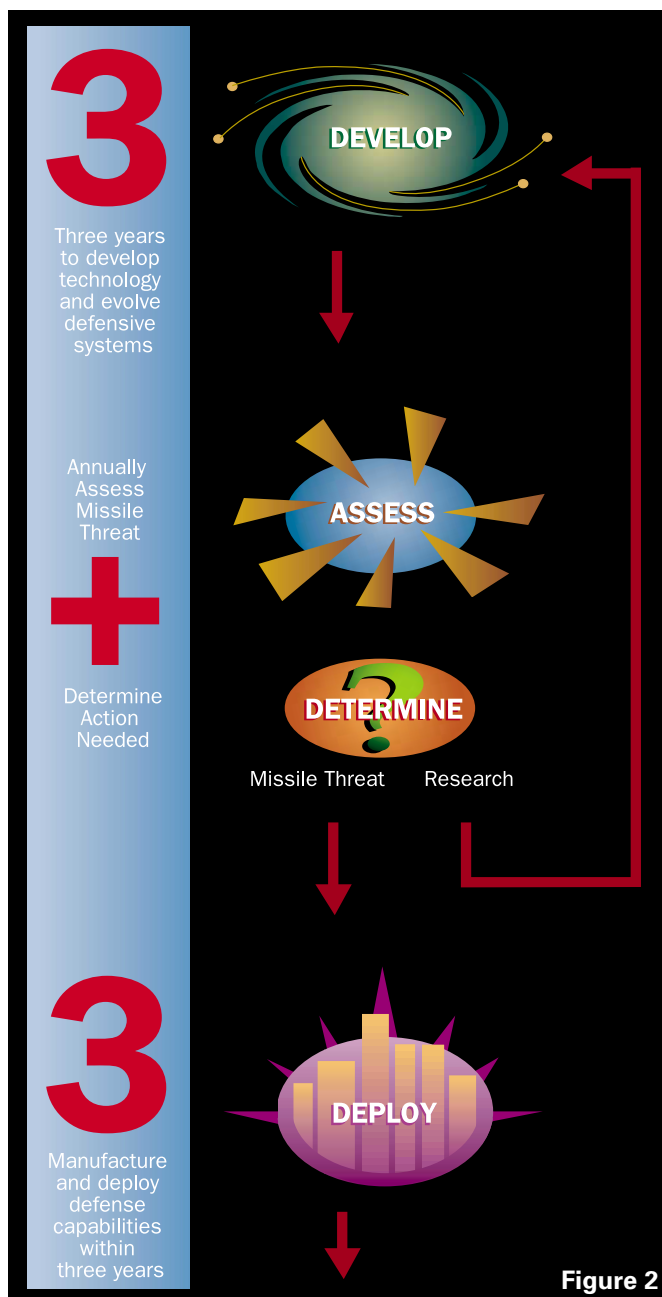
SS-25

1983, President Reagan put the United States on a course aimed at developing a space-based global protection missile-defense system. The policy’s objective was to add a new decisive defensive component to the United States’ strategic posture. This proposal was quickly nicknamed “star wars” by the media and was greeted with skepticism by many policy and technology specialists. In addition, a number of factions raised objections to the implied requirement of U.S. withdrawal from the ABM Treaty and the possible effect that withdrawal could have on other arms-control regimes such as the Nuclear Non-Proliferation Treaty (NPT) and the Missile Technology Control Regime (MTCR). Eventually, a majority consensus formed around the opinion that a global protection system was neither politically nor technologically feasible in the immediate future.

² For example, see James C. Busert, “Russian Missile Defense Faces Challenges,” *Signal*, January 1996, p. 55. More recent articles continue to buttress the impression that the ABM system is falling into disrepair. For example, current officer manning levels for the site are reported to be 50 percent under the authorized level. See Anna Averina, “Russian TV Shows Moscow Antimissile Defense Facility,” *Moscow Center TV*, 1055 GMT, 21 February 1999, translated in FBIS, 23 February 1999. For an excellent overview of the systems development and current status, see Steven J. Zaloga, “Moscow’s ABM Shield Continues to Crumble,” *Jane’s Intelligence Review*, February 1999, 10-14.

as the SS-25 mobile missile), while still in the boost-phase of its trajectory. Since the SS-25 was judged to be a more likely candidate for involvement in an accidental-launch scenario, the viability of space-based missile systems were questioned in terms of their potential vulnerability and their overall utility against the more likely threat scenarios.

Third, there was significant opposition to the concept of basing weapons in space. The question of whether or not the United States wanted to be the first country to initiate an arms race in space proved troubling. When this question was examined by the arms control community, and when the benefits of space-based weapon systems were reviewed in the context of the end of the Cold War and the diminishing prospects that Russia might launch a massive nuclear strike against the United States, it became clear that the United States was not prepared to make the political decisions necessary to proceed with the deployment of space-based missile-defense weapon systems



Subsequently, the U.S. national missile defense program mutated into a less ambitious undertaking, one now aimed at developing and deploying a family of tactical ballistic missile defense systems while concurrently developing a capability to deploy (if so ordered) a limited ground-based national missile defense system. As noted before, the earliest that a high-risk development program could field an elementary ground-based NMD system is 2003, with 2005 now being proposed by the administration for fielding of the same initial capability, but with less schedule risk as the system developers would have more time to integrate, test, and debug the system.

As it now stands, a national missile defense capability will not be fielded until 2005. Although there had been an agreement in 1996 between the administration and the Congress to pursue what became known as the NMD 3 + 3 program (see figure 2), the Department of Defense failed to fund the development effort at the level needed to deploy the program by 2003.³ This program called for a three-year effort to develop

³ The Under Secretary of Defense, John Hamre, reportedly acknowledged this fact during Senate testimony. See "DOD Studies Whether Navy Missile Could Work For THAAD," *Defense Daily*, 5 October 1998.

technology and to evolve the defensive systems needed to field a very limited National Missiles Defense capability against possible missile attack by Third World actors.

Beginning in the year 2000, an annual review of emerging missile threats was to be undertaken to determine whether or not the immediate deployment of an NMD system was warranted. Once it was determined that the missile threat to the United States required a national missile defense response, a limited missile defense capability was to be built and fielded within three years, one capable of defending all 50 states. Under this program, 2003 was the earliest that a limited NMD system could be physically deployed. It was also recognized that this rapid deployment would constitute a high-risk development program since decisions would have to be made to build sites and infrastructure before the various system components were fully designed, system integrated, and proven technically effective.

With Secretary Cohen's 20 January 1999 statement, the status of the 3 + 3 program is now in question. During his testimony before the House Armed Services Committee on 2 February 1999, Mr. Cohen indicated that the administration's program aimed at a possible deployment of an NMD system in 2005, but that the 3 + 3 program could still be mandated by Congress or "...if technology matures that much faster, we could still try to hit the 2003."⁴ At the same time, the U.S. Secretary of State, Madeleine Albright, made a clear statement in Moscow that "...deployment under any circumstances would not happen until 2005 if the threat situation continues and if, in fact, these kind of systems are feasible; the national missile defense is what I am speaking about."⁵

The United States is simultaneously conducting an advanced technological demonstration program that could provide the country with an option of deploying a space-based missile

defense system. Several missile defense technologists projected that it would require 15-20 years and a large expenditure of funds to develop and deploy a space-based laser constellation capable of engaging a major missile attack. Thus, the compromise near-term NMD effort has been focused on the development of a limited ground-based missile defense, with a space-based defense possible in the future if required by the threat and if deemed politically feasible by U.S. policymakers.⁶

⁴ House Armed Services Committee Hearing, "Fiscal Year 2000 Department of Defense Budget," *Congressional Record*, 2 February 1999.

⁵ U.S. Department of State, "Secretary of State Madeleine K. Albright and Russian Foreign Minister Igor Ivanov Joint Press Conference," 26 January 1999.

⁶ This discussion does not include the option to field a *Brilliant Pebbles* type of defense system since the United States has stopped working on that system.

BOEING (TRW) EKV

(Held in backup status -- cancelled May 2000)

The Boeing EKV is built in three modules (forward, middle, rear) to facilitate easy component upgrade as future advancements in technology evolve. For example, the EKV has the capability to be upgraded to incorporate a laser radar (if developed). Navigation is provided by an on-board GPS receiver connected to an inertial navigation system by fiber-optic cable, with star navigation incorporated as a backup system. The entire unit weighs just under 100 pounds.

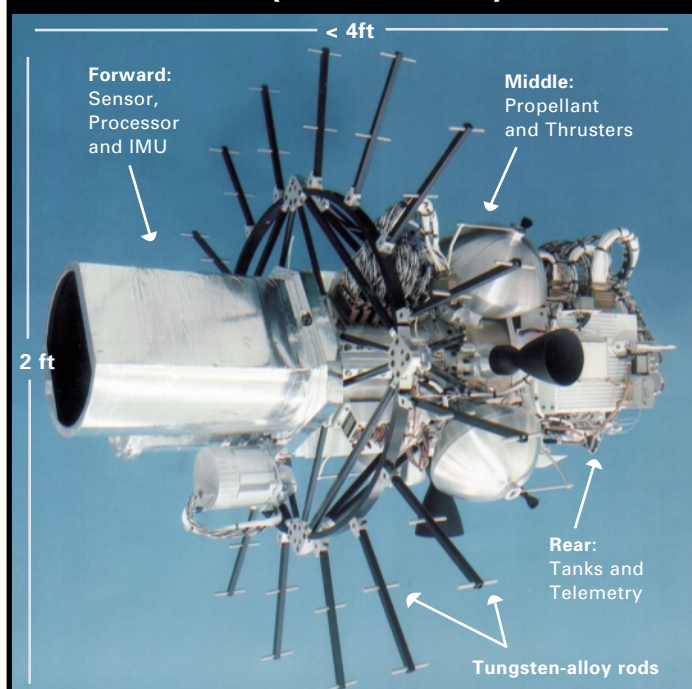
The sensor is a telescope linked to a very sensitive arsenic-doped-silicon focal-plane array able to detect infrared electromagnetic wavelengths up to 26 microns (VLWIR). The key technical aspects of the Boeing sensor are:

- The silica sensor must be cooled to 13° K (-260° C) to detect infrared signals. This is accomplished during fly-out using a two-stage device that first injects nitrogen into the inner and outer chambers of the cooler and, at a calculated moment, induces hydrogen into the inner chamber, forming a solid hydrogen "ice cube" which then gradually sublimates into its gaseous state keeping the focal plane at a constant frigid temperature. It requires about 1.5 minutes for the cool-down process to occur. The sensor must be cooled for the last two minutes of the mission.
- A filter allows only two widely separated IR wavelengths to pass through to the focal plane; the two measurements allow the relative temperatures of target array objects to be determined.

- Silica-based IR sensors, while losing all IR detection capability at temperatures above 14° K, have advantages in that silica is resistant to nuclear effects, tends to maintain calibration and is responsive to a large proportion of the IR spectrum, especially at the very long IR wavelengths.

This EKV was designated as the backup system for the Raytheon EKV. This program was terminated in May 2000.

BOEING (ROCKWELL) EKV



Sources: *Aviation Week & Space Technology*, March 3, 1997,