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Planning a Ballistic Missile Defense System of Systems

An Adaptive Strategy

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INTRODUCTION

The United States is edging toward deployment of a national missile defense (NMD) system to protect itself from limited ballistic missile attacks by rogue nations.[1] Although a definitive decision to deploy NMD has not been made, the Clinton administration is taking steps in that direction: (1) affirming that a rogue nation ballistic missile threat could exist in the near future, (2) budgeting funds for NMD deployment in the Future Years Defense Program, and (3) declaring that NMD deployment might require modifications to the Antiballistic Missile (ABM) Treaty. The administration has promised a deployment decision as early as July 2000, assuming the technology is ready and the threat looms. Congress appears even more committed, with both the House and Senate recently voting to deploy a system as soon as technologically possible.

This growing interest in at least limited NMD has been fueled by concerns about the spread of weapons of mass destruction (WMD), ballistic missiles, and technologies to produce both. Three particular developments in 1998 catalyzed the push to deploy: (1) the nuclear tests by India and Pakistan, which validated fears of further nuclear proliferation; (2) the Rumsfeld Commission report, which found that the ballistic missile threat to the United States is broader, more mature, and evolving more rapidly than originally surmised and that it may emerge with little or no warning (Rumsfeld, 1998); and (3) the Taepo Dong-1 missile test by North Korea, which reinforced the Rumsfeld Commission findings by illustrating that key technological hurdles to intercontinental ballistic missile development (in this case, multiple staging) may be overcome without warning.

Yet, with both widening support and a heightened sense of urgency for at least limited NMD, there is a danger that the United States will take a path of least technical, bureaucratic, and diplomatic resistance, instead of making a considered judgment of what missile defense capabilities and treaty rights it needs. Current plans for a near-term NMD—the so-called "C1 capability"—are essentially a point solution to a point problem, with limited long-term value. At worst, the current plans point to a fragile initial capability that may be inadequate even to meet the immediate threat, much less other threats. It follows that negotiating only those changes to the ABM Treaty needed to permit the planned point solution will either prevent the United States from having adequate missile defense or require more wholesale treaty changes down the road.

A different point solution is not the answer. What is needed, instead, is a long-term strategy that addresses the evolving ballistic missile defense problem broadly and flexibly, while also neutralizing the near-term threat. This strategy would call for an integrated and adaptable "system of systems" to defend U.S. territory, forces, allies, and other interests worth protecting. Such an approach is essential for coherent investment, technological, and negotiating strategies and should therefore be crafted in paral-

[1] The system would also have some inherent capability against small accidental or unauthorized Russian or Chinese launches.

lel with—indeed, as the framework for—a response to the immediate threat.

In this paper, we present the case for and the components of such a general solution. We offer a durable strategic rationale for a ballistic missile defense, suggest how to assess the adequacy of any solution, illustrate a general solution, and identify potential steps to align the near-term program with the general solution. We also examine strategies for managing the ABM Treaty, Russia, China, and strategic offensive forces that are consistent with the general solution. To set the stage, we begin with a brief description of current U.S. ballistic missile defense programs and the ABM Treaty.

WHERE WE ARE TODAY

National Missile Defense

As Defense Secretary William S. Cohen defines it, "the primary mission of the NMD system being developed is the defense of the U.S.—all 50 states—against a limited strategic ballistic missile attack such as could be posed by a rogue nation." (Cohen, 1999.) The current NMD program envisions an initial land-based system that can defend against such an attack and evolve to counter future threats. Toward this end, the Ballistic Missile Defense Organization (BMDO) defines three levels of capability to meet three levels of threat: the C1 capability, capable of defending against a few unsophisticated reentry vehicles (RVs); C2, against a few sophisticated RVs; and C3, against many sophisticated RVs (Department of Defense [DoD], 1998).

The C1 capability (see Table 1) will likely employ a limited number of interceptors carrying kill vehicles that can home in on targets outside the atmosphere, using infrared optics for "hit-to-kill." One launch site (either in North Dakota or Alaska) collocated with a tracking radar is the current plan. The C1 system will use upgraded early warning radars at five locations and will rely initially on Defense Support Program (DSP) infrared satellites for launch detection and cueing.[2] Over time, Space-Based Infrared System, High Component (SBIRS High) satellites will replace DSP in this role. Initial battle management/command, control, and communications (BMC3) will be performed at the strategic command complex in Cheyenne Mountain, Colorado.

[2]Infrared satellites detect launches by observing the bright plume of the missile during boost. Such observations may be used to cue early warning radars to begin searching an area of the sky. Normally, these radars would, in turn, cue a tracking radar, which would aid the interceptor in finding the target. Discrimination—determining real targets from the field of debris, other clutter, and countermeasures—would ideally be accomplished by fusing data acquired by each sensor in the chain.

Table 1
NMD Capabilities and Threats

	NMD Capability	NMD Threat
C1 (c. 2005)	20 ground-based interceptors 1 tracking radar Upgraded early warning radars DSP/SBIRS High Initial BMC3	A few simple ICBMs No countermeasures
C2 (c. 2010)	100 ground-based interceptors Additional tracking radars Discrimination upgrades SBIRS High/Low Enhanced BMC3	A few advanced ICBMs Countermeasures
C3 (c. 2015)	Ground-based systems (in place) Sea-based options Space-based option	Many sophisticated RVs

The C2 capability will employ more interceptors, additional tracking radars, and various target discrimination and BMC3 upgrades. Additional launch sites may be another possibility. Over time, SBIRS Low satellites capable of infrared tracking in the ascent and midcourse trajectory phases will provide more advanced capability against enemy countermeasures. To date, the C3 capability remains unspecific, but it could involve sea- and space-based kill systems.

Theater Missile Defense

Patriot's lackluster performance against Iraqi Scud missiles and the U.S. inability to destroy mobile missile launchers in the Gulf War generated considerable interest in theater missile defense (TMD) to protect U.S. allies and deployed forces against shorter-range missiles (typically defined as having a range of 3,500 km or less). The resulting, and current, DoD TMD "core" program consists of four systems using hit-to-kill interceptors (see Table 2):

- Patriot Advanced Capability-3 (PAC-3) is designed to intercept missiles at altitudes below 25 km (low-endoatmospheric), acquiring its targets using a radio-frequency seeker.
- The Navy Area Theater Ballistic Missile Defense (TBMD) utilizes an enhanced Standard Missile for low-endoatmospheric intercept, homing on targets with an infrared seeker. Navy Area TBMD exploits

Table 2
TMD Active Defense Systems and Capabilities

TMD System	TMD Capability	First Unit Equipped (est.)
PAC-3	Low-endo intercept	2001
Navy Area TBMD	Low-endo intercept	2003
THAAD	High-endo/exo intercept	2007
NTW TBMD	Exo intercept	2007
Airborne Laser	Endo/exo intercept (boost-phase)	TBD

the considerable investment already made in AEGIS cruisers and destroyers equipped with SPY radars.

- The Theater High-Altitude Area Defense (THAAD) system targets missiles at altitudes above 40 km, both inside (high endoatmospheric) and outside the atmosphere (exoatmospheric). THAAD is a ground-based system using infrared terminal guidance.
- Finally, the Navy Theater-Wide (NTW) TBMD system intercepts missiles exoatmospherically (at altitudes in excess of 100 km), also using infrared homing and AEGIS sea-basing. The Pentagon hopes to combine the NTW and THAAD programs after 2000, with the system that does better in overall program performance becoming the lead upper-tier system.

The core program consists of only land and sea components. Beyond these, the lead air component is the Airborne Laser (ABL), a Boeing 747 with a high-powered chemical laser capable of intercepting ballistic missiles during boost. Endoatmospheric intercept of the burning rocket booster is planned; absent range constraints, exoatmospheric intercept of the booster should also be possible, provided it continues burning above the atmosphere.

The ABM Treaty

Deploying effective ballistic missile defense—certainly NMD—will require changing the 1972 ABM Treaty, which was meant to constrain U.S. and Soviet capabilities to defend themselves against strategic nuclear attack. The original U.S. motivation for the treaty was mainly to avoid a costly race to deploy extensive missile defense systems that probably would not work yet would intensify pressures to increase offensive strategic nuclear forces. In some quarters, the ABM Treaty was considered crucial for strategic stability in that it protected the ability of each power to retaliate, even after receiving a nuclear first-strike from the other. Several constraints of the ABM Treaty regime are particularly relevant to the current policy debate:

- Article I proscribes each party from deploying ABM systems for a defense of the territory of its country.[3]
- Article III allows each party to deploy limited defenses at two sites only: one within 150 km of the national capital, and another within 150 km of an ICBM silo field. Up to 100 ABM interceptors and launchers may be located at each site, and the site must contain all ABM radars.
- A 1974 Protocol states that only a single site may be deployed at any one time and, accordingly, that the United States may not deploy around its capital, and the Soviet Union may not deploy around its ICBM silo fields. The Common Understanding is that the U.S. site will be around Grand Forks, North Dakota.
- To help ensure that ABM defenses shall only be fielded in accordance with Article III, Agreed Statement D stipulates that ABM systems based on other physical principles, including ABM components capable of substituting for interceptors, launchers, or radars, would require agreement of the parties.
- Article V prohibits the development, testing, or deployment of sea-based, air-based, space-based, or mobile land-based ABM interceptors, launchers, and radars.
- Article VI prohibits interceptors, launchers, or radars—other than those allowed under Article III—from having the capabilities to counter strategic ballistic missiles in flight.
- Further prohibitions include testing non-ABM systems in an ABM mode; the deployment of early warning radars except around the country's periphery, oriented outward; and phased-array radars exceeding a certain capability.

The treaty is ambiguous about whether operating and testing highly capable TMD systems would violate Article VI.[4] Therefore, in their 1997 Joint Statement, the United States and Russia agreed on elements of a demarcation agreement on higher-velocity TMD systems that would (1) limit the velocity (to 5 km per second) and range (to 3,500 km) of target missiles used to test such systems; (2) proscribe the development, testing, or deployment of space-based TMD interceptors or components based on alternative technologies that could substitute for such interceptors; and (3) call for consultations in the event new technologies arise for use in TMD systems.

We will return to the treaty later. For now, it should be clear that a minimal point solution to the point problem, as defined above, could require renegotiation of a few specific sections of the treaty—perhaps no more than the Protocol and Common Understanding limiting the number and location of land-based sites. By the same token, the more robust the solution to the nation's NMD needs, the more sweeping the treaty changes required. In other words, the ABM Treaty is, as it was intended to be, a barrier to effective and adaptable NMD. Therefore, before addressing negotiating aims, it is important to understand

[3]The official U.S. position is, in essence, that a party is in compliance with Article I so long as it is in compliance with the rest of the treaty.

[4]From the beginning, it was recognized that even early TMD systems (indeed, even some air defense systems) would, in fact, be able to "counter strategic ballistic missiles in flight" to some extent. This matter was discussed in the treaty negotiations and in verification negotiations in which the United States complained about suspicious Soviet tests of the SA-5 air defense system.

what an effective and adaptable defense solution would entail.

THE NEED FOR A GENERAL SOLUTION

A Caution About Point Solutions

Again, the NMD system now under development is designed for a very specific problem: a small, unsophisticated, ground-launched, northern-hemispheric or -polar ballistic missile attack on U.S. soil. The most pressing concern is the not-too-distant feasibility of a small-scale attack by crude North Korean ballistic missiles bearing nuclear or biological weapons, a concern based not only on the recent Taepo Dong test but also on Pyongyang's continuing interest in WMD. The fact that the North Korean regime may be teetering on the edge of collapse is of little consolation, given the risk that it could lash out in its final days.

We do not belittle the importance of deploying a defense against this threat by the time it appears.[5] But a rushed point solution to this immediate problem, however much needed, is not an adequate approach to a general problem that will be more complex, mutable, and widespread—and is sure to be with us long after the North Korean regime is history. The strategic rationale for NMD is not to knock down a Taepo Dong missile; that could be one tactical use. Rather, it is to deny hostile states an ability to coerce the United States by threatening to kill large numbers of Americans. Therefore, while there may be reason enough to field a specific capability by 2005, the general solution must work indefinitely and broadly.

In this era of flux—and there is no sign that the future will be different—it is important to explore an entire *space* of plausible future threats and circumstances as the way of testing the robustness of any solution in the face of uncertainty and change. This is the essence of exploratory planning (see, e.g., Davis, Gompert, and Kugler, 1996), which seeks to ensure that capabilities are not exquisitely tailored for one plausible future only to fit poorly all others—most importantly, of course, the one that eventuates. This way of thinking is as important in ballistic missile defense as it is in any defense area.

To be fair, the developers of the C1 system recognize the desirability of "openness," and their design appears to leave modest room for future enhancement (i.e., to C2). But we are doubtful about its long-term adaptability, given its inherent limitations and the dynamic nature of the ballistic missile threat. While it cannot be ruled out that this point solution is an ideal first step toward a general and versatile solution, neither logic nor analysis has been produced to indicate that it is. C1 has been devised against a specific threat, under some time pressure and associated technical limitations. We need only reflect on the changes in the world security environment in the past decade—regional transformations, technology diffusion, collapsing and rising powers—to doubt that the immediate threat well represents those of the decades to come. Facing such uncertainty, and technological opportunities known and unknown, it is reasonable to question the premise that firing interceptors from U.S. soil to produce head-on collisions, at extraordinary relative velocities, with missiles descending in space, is the ideal way to defend that same soil.

It is better to know now, rather than later, whether the chosen point solution is unsuitable for other plausible future threats and cannot be adapted readily and affordably to meet them. Perhaps the point solution should be implemented anyway, for lack of other practical options in the face of an immediate threat. But then, complementary capabilities should be developed—less urgently but in parallel—to address as much as possible of the remainder of the general problem. Otherwise, the point solution will fail, or at best prove inadequate, as the problem grows, spreads, and evolves. The great danger is that the point solution can become a sink for funding, based on exaggerated confidence and vested interests, especially as the threat becomes more challenging. In any case, a general solution envisioned early on should influence the design of the initial system, insofar as the latter could then be seen as a cog in the former.

Why This Point Solution Is Especially Fragile

Even under ideal circumstances and with the latest technologies, ballistic missile defense is exceedingly difficult. Destroying an RV in flight requires an end-to-end sequence of successful tasks: detecting and classifying the threat missile, predicting the threat trajectory, cueing sensors down the line, tracking the target, discriminating the target from clutter and countermeasures, acquiring the target for intercept, intercept, kill assessment, and repeating the sequence as required. A failure anywhere in this chain precludes successful intercept.

Countermeasures compound these challenges. These might be sophisticated penetration aids capable of spoofing defensive sensors across a variety of frequencies. But they might also be simpler measures that could be within reach of a rogue nation advanced enough to weaponize

[5]The August 1998 Taepo Dong test included an unanticipated third stage. Although this stage failed, the test demonstrated multiple stage separation, an important ICBM development milestone. When the North Koreans resolve the technical issues resulting in that failure, their three-stage configuration could likely deliver small payloads (perhaps enough to carry a biological weapon) to ranges in excess of 5,500 km. Thus, mainland Alaska and the Hawaiian Islands may soon be within reach of their missiles.

and deliver a nuclear or biological warhead. Table 3 contains examples of such countermeasures.[6] Ballistic missile launches create a certain amount of natural debris—propellant tanks, booster stages, other pieces of the rocket body—that can complicate the problem of identifying RVs. Detonating an explosive within spent missile stages can increase the number of objects in the debris field, complicating this problem further. Painting RVs can reduce their infrared signature. Chaff can interfere with radar performance. Balloons inflated exoatmospherically can serve as decoys or mask the target RV. Other decoys might include infrared flares or objects with radar cross sections similar to that of an RV. Radar-absorbing material could be applied to reduce radar cross section, while small radar receivers/transponders could "mask" normal radar return through deceptive jamming (Frankel, 1997).

Just as decoys can be made to appear real, the signature of real RVs can be modified to appear like that of debris. Even the launch trajectory of the missile can be shaped in a way to confuse trajectory estimation by the defense, which, in the near term, relies on fitting boost-phase measurements to trajectory templates.[7] Compared to other countermeasures, however, trajectory shaping may be more difficult for rogue states to engineer with confidence.

Submunitions may be the most vexing countermeasure of all. By packing bomblets into a postboost vehicle for release above the atmosphere, adversaries may at once disperse their weapons over a larger footprint and overwhelm midcourse and terminal defenses with a large number of targets.

The current point solution does not adequately address such countermeasures.[8] Moreover, target missiles can do other things that complicate defense. For example, RVs that are not spin-stabilized will tumble, necessitating longer dwell times for target discrimination. Since it is more likely than not that a rogue-nation RV would tumble, this may be particularly important in the near term.[9] Inadvertent, unpredictable events can also be problematic. Witness, for example, the Iraqi Scuds in the Gulf War: The warheads did not separate from the missile body, which was elongated and unbalanced by reverse engineering, resulting in the entire missile assembly tumbling through space and back into the atmosphere (Postol, 1991). Such

Table 3
Countermeasures That Can Degrade Defense Effectiveness

Detonating cords	Radar decoys
Paint	Radar-absorbing material
Chaff	Deceptive jamming
Balloons	Trajectory shaping
Infrared decoys	Submunitions

events can wreak havoc with discrimination techniques designed with a precise target in mind.

With a limited interceptor inventory (20), the point solution is also vulnerable to a growth in offensive missile arsenals. This solution calls for salvo launches of interceptors to ensure high confidence that no warheads will penetrate the defense. Depending on the single-shot kill probability that is ultimately achieved, salvos as large as four interceptors could be required, in which case the point solution could defend against a total of only five RVs. If a sixth RV were incoming—perhaps launched by a second rogue—the United States would be defenseless. Bear in mind that, once a rogue state is able to field a ballistic missile capable of delivering a crude WMD at intercontinental range, its arsenal of such missiles could be increased relatively rapidly.

Geographical coverage is also limited. With interceptors and X-band radar at Grand Forks, the point solution would have difficulty protecting Alaska and Hawaii against a northeast Asian launch. With an Alaskan site, U.S. islands in the Caribbean would be unprotected against a Middle Eastern launch (DoD, 1998). If the system's performance turns out to be less than now envisioned, or if threat missiles follow depressed trajectories, a single deployment site could leave even more U.S. territory unprotected. Even with two sites, currently conceived U.S.-based interceptors are far from ideal for defeating southern-hemispheric threats. Although no such threats can be foreseen today, they cannot be excluded from the general problem over the long term. More important, the current program is poorly suited to defeat sea-based threats, which are plausible.[10]

In summary, the main limitations of the point solution are its inability to handle simple countermeasures,[11] its small interceptor inventory, and its inability to defend U.S. territory against all launch locations. These three limitations render the point solution inherently fragile.

[6]For further discussion of ballistic missile defense countermeasures, see Sirak (1999a, 1999b), Tanks (1997), and American Physical Society (1987).

[7]Trajectory estimation algorithms are key in predicting the launch point, impact point, and target location for cueing other sensors.

[8]The C1 capability should, however, be able to discriminate targets from natural debris.

[9]Tumbling is the "natural" state of an RV. Spin stabilization—which eliminates tumbling—increases the accuracy of an RV, which may not be

[10]With adequate sensor coverage, the problem of interceptor "reach" is easier to solve. Thus, sensors are an important consideration in any attempt to mitigate geographical coverage limitations. Indeed, many would argue that sensor restrictions provide the key ABM Treaty constraint on defense effectiveness.

[11]Of course, submunitions and balloons may confound even more robust ballistic missile defense constructs relying on midcourse intercept.

Defining the General Problem

Fashioning a more stable, robust solution to the general problem must begin by understanding the dimensions of that problem. The cube in Figure 1 illustrates the general problem, or the space of plausible ballistic missile threats over the middle to long terms.

Point A is the threat that the currently planned system is designed to defeat: small, unsophisticated, geographically localized—the easiest threat to counter. Point B is a small and unsophisticated threat or combination of threats whose physical location is either unknown (e.g., because of its mobility) or known but widely dispersed. Point C is a small threat with both high location uncertainty and high sophistication (e.g., penetration aids). And Point D is a large, sophisticated and geographically distributed threat, comparable to the current Russian threat (assuming missile-bearing submarines are on patrol) and a possible future Chinese threat (also with submarine-based and/or land-mobile missiles).

When its proponents say the currently planned NMD system is adaptable, do they mean that it could evolve gracefully or be enhanced rapidly toward points B, C, and/or D? Put differently, were the United States to plan a solution for, say, point C, would it concentrate its efforts on building a land-based interceptor site in Alaska, relying on head-on, hit-to-kill intercept? Would it not, for example, consider using the vastness of the oceans and space; the advantages of mobility; and different, possibly multiple intercept points, mechanics, and angles? Would it not put heavier emphasis on boost-phase intercept? Would it not exploit intercept mechanisms other than hit-to-kill?

The current program, if it works as planned, should solve problem A, assuming the threat "cooperates" by remaining fixed. The current program may indeed be the most cost-effective, if not the only, solution to problem A available in the next five or so years.[12] That said, we believe that analysis of other regions of the space of plausible threats would reveal that the NMD system now under development cannot easily grow into a solution to the general problem, if only because of geographic limitations.

It happens, not entirely by coincidence, that the favored (C1) solution to problem A probably involves less rewriting of the ABM Treaty than any other concept—namely, the right to have a different interceptor launch site in Alaska. It is also the case, and logically follows, that

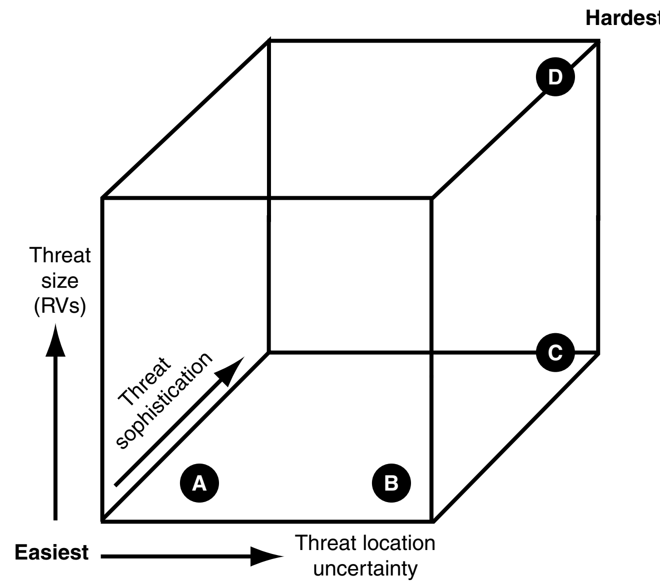

Figure 1—The General Problem

modifying the ABM Treaty exclusively to permit this point solution to problem A would be far too restrictive to solve the general problem. For instance, the treaty's ban on sea-based and space-based ABM systems would not interfere with the chosen solution to problem A but could prevent or badly compromise a solution to the general problem. So well crafted is the ABM Treaty that any solution accommodated by changing it slightly is by definition suspect as the basis for effective and adaptable NMD. Conversely, solving the general problem might require an ABM arms control regime so much more permissive than the current one as to raise a question about that regime's meaningfulness. If one is serious about missile defense, it is better to know now how drastically the ABM Treaty will eventually have to be modified than to assume that minor changes will suffice indefinitely.

Apart from the ABM Treaty, we might choose to rule out, even for the long term, some regions of the space of future ballistic missile defense needs. In particular, it can be argued—and the authors happen to believe—that the United States need not and should not, for the foreseeable future, build a defense against large-scale ballistic missile salvos, e.g., launched by Russia or China. Barring any interest in being able to launch a disarming U.S. first strike against either country (in which case highly capable NMD would be crucial), we should count on deterrence to work against both. Moreover, we do not wish to stimulate a costly and destabilizing defensive-offensive strategic arms race with one or the other power, when our main concern is the rogue threat. Thus, we could, and will, restrict our definition of the general ballistic missile defense problem to the lower part of the cube, as shown in Figure 2.[13]

[12]In "Aligning the Point Solution with the General Solution," below, we will look at the risk that the current point solution will be inadequate even for problem A by the time that problem materializes.

[13]For a precise, analytic-based demarcation, see Wilkening (1998).

Of course, it is easier to distinguish Russia than it is China from the "rogue threat," not because China is more roguish but because its long-range missile force is much smaller than Russia's and likely to remain so. As a consequence, it should be easier to convince Russia than China that U.S. missile defense is not a threat to its strategic deterrent capability. The larger the rogue threat the U.S. missile defense is designed to defeat, the less confident the Chinese will be that they have an adequate deterrent. The challenge of managing this issue is taken up below (see "Managing the ABM Treaty, Russia, China, and Offensive Forces"). The point to be made here is simply that one need not include a Russian or Chinese threat to be concerned about the sophistication, the uncertain location, and the size of future threats.

OUTLINE OF A GENERAL SOLUTION

The Purpose of Ballistic Missile Defense

Hypothesizing a general solution to the problem space in Figure 2 must begin with a durable rationale for having the ability to defeat rogue ballistic missile attacks. In this regard, the political debate surrounding today's point problem can be misleading, because its motivation, like its operational function, is to prevent a particular state, such as North Korea, from attacking U.S. territory with ballistic missiles armed with WMD. The proper strategic rationale, however, is broader and more nuanced. It goes to the heart of the *ability* and *will* of the United States to protect its global interests and meet its international responsibilities in the contemporary era.

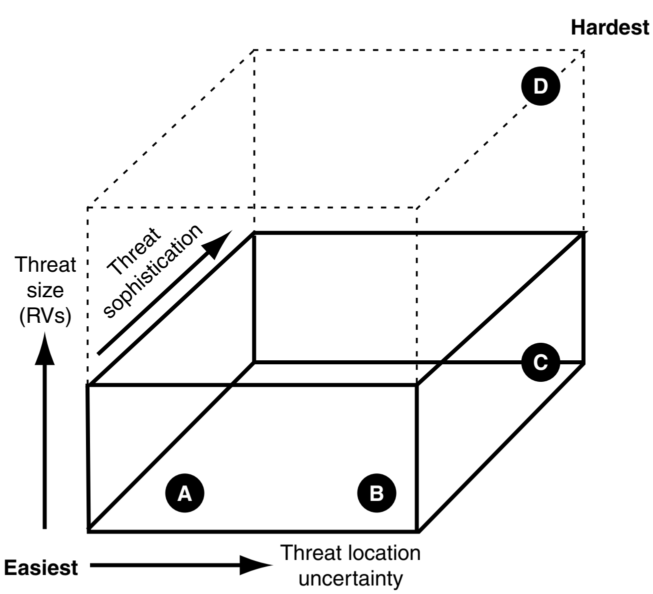

Figure 2—General Problem Restricted to the Rogue Threat

The reason the general problem is worth solving is not that some rogue would otherwise launch an unprovoked, and patently suicidal, nuclear or biological attack on U.S. territory. Rather, it is that in the face of utter defeat by U.S. conventional forces, an enemy regime could threaten such an attack in order to deter the United States—and conceivably carry out the threat if the United States were not deterred. An unprovoked attack is far-fetched; a coercion scenario is not. Perhaps such a threat would backfire, producing even greater American fury in response to it. However, the United States might be paralyzed if so threatened, especially if it thought the adversary might be desperate enough to make good on the threat.

So ballistic missile defense is not simply a *shield* but an *enabler* of U.S. action. Although the United States presumably would not be deterred by a rogue's missile threat from intervening abroad to protect literally vital U.S. interests, the inability to act in defense of less-than-vital interests would severely undermine the U.S. international role and the peace and security that depend on that role.

If deterrence suffices to forestall attacks by the large forces of established nuclear powers, why are we less sure when it comes to a small attack by a rogue? After all, a rogue would be more vulnerable than Russia or China to a devastating U.S. retaliatory strike. We see several reasons to consider the rogue-state threat particularly worrisome:

- First, rogue states with small arsenals would be far more vulnerable to a disarming U.S. preemptive strike, giving them a more sensitive trigger finger than Russia or China.
- Second, as noted, a rogue might threaten a WMD attack with ballistic missiles in order to deter the United States from intervening against it. If the United States is perceived as intent on the enemy regime's extinction anyway, what is lost by at least making such a threat against the United States? While it cannot be ruled out, it is far less likely that China or Russia would be provoked by plausible U.S. interventions to make such a desperate counterthreat, knowing it could lead to nuclear holocaust.[14]
- Finally, a rogue might be more inclined than Russia or China to use biological and chemical weapons, yet not be convinced that the United States would retaliate

[14] Either the United States would avoid such a provocation, or China and Russia would not respond to one by threatening a nuclear attack, which could trigger a U.S. first strike. The toughest "test case" for such an assumption would be a U.S.-Chinese confrontation over Taiwan: While the United States might be willing to risk war with China to save Taiwan, it is hardly plausible that China would risk its own destruction by launching a nuclear first strike on the United States just to acquire Taiwan.

with nuclear weapons for a biological or chemical attack. So deterrence might work less well against small non-nuclear threats of the sort a rogue might make.

The strategic purpose of ballistic missile defense, then, is to negate the effectiveness and likelihood of rogue ballistic missile threats aimed at deterring the United States with WMD. Given this purpose, the general problem includes all the ways in which such a rogue could threaten or use ballistic missiles with WMD to disrupt, derail, defeat, or retaliate for the U.S. projection of power against it. The general solution, therefore, must counter all these threats.

Furthermore, because the threats are interrelated—varying mainly in range—and the technologies for responding to them are also interrelated, the general solution ought to be integrated. Piecemeal responses to ballistic missile threats ignore the opportunity to bring to bear related technologies on the largely common phenomena of ballistic flight. In no contemporary military operation is the case for jointness clearer.

Thus, in considering both the general problem and the general solution, the dichotomy between NMD and TMD is not entirely helpful. It ignores the spectrum of ways and ranges in which an inferior enemy could use ballistic missiles armed with WMD toward the same end: to undermine the will and the ability of the United States to project power. It is better—though awkward in light of the ABM Treaty and the history of various DoD programs—to conceive of a multifaceted solution to defend U.S. territory, forward-deployed U.S. forces, U.S. forces engaged in combat operations, key host countries, and allies.[15]

Such a solution should be able to counter ballistic missile threats of most any range, including those incapable of striking U.S. territory but nevertheless able to weaken U.S. power-projection capability or will. The inability to defend U.S. expeditionary forces against a credible, short-range, ballistic missile threat involving WMD could be a strategic vulnerability if it inhibited the United States from protecting important overseas interests.

A strategic solution should also exploit the advantages of intercept in all stages of trajectory, not just late midcourse (i.e., postapogee, exoatmospheric). In addition to the advantages of each type of intercept, high-quality defense—that is, a high confidence of zero "leakers"—would benefit from multiple layers. Thus, the concept of layering currently applied to TMD should apply to ballistic missile defense (TMD plus NMD) as a whole.[16] Indeed, if layering is desirable and feasible for the defense of U.S. forces, bases, and allies, it is even more compelling for the defense of U.S. soil. Finally, a general solution should be able to cope with or adapt readily to meet threats of increasing sophistication, scale, location uncertainty, and geographic distribution.

An Illustrative Ballistic Missile Defense System of Systems

With these tests of adequacy in mind, a hypothetical general solution might include, at one end, a boost-phase intercept capability to destroy ballistic missiles of short,[17] intermediate, and intercontinental range, and at the other end, fixed, U.S.-based, late-midcourse territorial defense. Even if boost-phase intercept were mastered, territorial defense would be needed because warning might not be sufficient to deploy and employ the former and because high confidence of zero leakage would demand multiple defense layers. In terms of current programs, a system like ABL might fill the boost-phase need and C1 or C2 the U.S.-based need.

In between boost-phase intercept and U.S.-based territorial defense, a general solution might employ a highly mobile component that could, with some warning, deploy to defend U.S. troops, allies, and other critical interests overseas. Such a component would intercept ballistic missiles in early midcourse (i.e., postboost ascent through apogee), where, compared to late-midcourse intercept, it would have the advantage of lower relative intercept speed and more favorable intercept geometry. Indeed, if sufficiently mobile and effective, it could become the workhorse of the system of systems because of its flexibility and contribution to both homeland and forward defense. One option might be to develop NTW into such a role; its mobility and versatility are inherent, and with an enhanced interceptor and access to space-based sensors, it might fill the gap between boost-phase intercept and U.S.-based territorial defense. An analysis of this and other options for mobile, early midcourse defense is needed.

Conceivably, a single-mode system—say, space-based directed-energy intercept using space-based global detection and tracking—could eventually "do it all." However, this possibility is by no means assured (even over the long term) and would not be ready in time to solve the near-term problem. It does not, therefore, obviate the need for the planned U.S.-based hit-to-kill system. Moreover, a single-mode system would lack the redundancy and

[15] This last point is not to suggest that the United States necessarily should, or has some obligation to, extend missile defense to all its formal allies but rather that such a need should be considered in evaluating a general solution.

[16] A discussion of layers in a TMD context may be found in Mesic (1994).

[17] In most plausible scenarios, extremely short-range missiles (e.g., 100 km) that burn out at relatively low altitude would be immune to boost-phase intercept capabilities.

adaptability of a system of systems and could therefore be vulnerable to failure or a well-focused countermeasure strategy. Finally, it might not provide sufficiently high performance at all points along the spectrum of threats.

At the same time, a ballistic missile defense construct encompassing boost-phase, early midcourse, and late-midcourse intercept could have a unified sensor and BMC3 network, in which SBIRS High and Low would play a leading role. By space-basing the main components of this single network, each defense subsystem could more readily exploit its benefits.

Testing the Adequacy of a Ballistic Missile Defense System of Systems

Determining whether our hypothetical ballistic missile defense construct, integrated by common BMC3 and sensors, would "solve" the general problem obviously would require more thorough analysis than can be presented here, or than has actually been done—although BMDO has produced a relevant body of analysis. However, a useful test can be performed by considering how well it would cope with three increasing challenges of the general problem sketched earlier:

- *Threat growth*: A solution with continuous coverage of enemy missiles, from ascent through late midcourse, would require fewer interceptors than a single-layer or discontinuous system to achieve the same results. If each successive layer can, on cue, concentrate on targets that leak through previous layers, the number of interceptors per target can be reduced without reducing confidence. In addition, the mobility of the solution's boost-phase and early midcourse components would permit the surging of the system to concentrate on suspected threats. Finally, a system of systems would offer more distinct technological options to improve kill probability in one or another layer, thus reducing the need to respond to more RVs with proportionally more interceptors.
- *Geographic uncertainty and distribution*: The deployable systems could provide virtually global coverage, depending on strategic warning. For a sea-based element, such warning need only be days or weeks—enough to respond in the sort of crisis in which a rogue ballistic missile threat with WMD would arise. Boost-phase intercept would have similar mobility, especially if airborne (though its coverage might be less extensive). At the same time, a U.S.-based element would hedge against failure to deploy the other components fast enough to meet a fast-developing threat. Also, this component would be the least vulnerable, insofar as forward-deployed aircraft and ships may have to operate in harm's way.
- *Threat sophistication*: Boost-phase intercept—when feasible—is the surest way to defeat most countermeasures because of both the opportunity to intercept before most countermeasures can be employed (especially submunitions) and the bright booster rocket plume that facilitates target acquisition.[18] The early midcourse component also helps by providing advantageous intercept ranges, angles, and relative velocities (i.e., slower than head-on).

Generally speaking, a system of systems is more adaptable because it permits improvement within any of its layers, depending on the evolution of the threat and the progress of technology. Such versatility is not free: A three-layer construct requires three technical and support pillars, albeit with some commonality and economies. However, as a practical matter, the United States is developing and might deploy most of the piece-part systems anyway, as explained above in "Where We Are Today." Integrating them, conceptually, managerially, electronically, and operationally, need not add greatly to the total cost.

Finally, although breakout potential against very large threats is inherent in such a system of systems, it could and should be sized to defeat, completely, an attack at the upper bound of what a rogue state would deploy—notionally, 50 or so RVs. This would be comfortably below the capability of Russia (though this would not exclude a negative Russian reaction). It could raise questions about the credibility of Chinese nuclear deterrence vis-à-vis the United States, which is all the more reason for the United States and China to seek a stable strategic understanding (see "Managing the ABM Treaty, Russia, China, and Offensive Forces").

ALIGNING THE POINT SOLUTION WITH THE GENERAL SOLUTION

The point solution poses two main risks. The first risk is that it will prove inadequate against even the point problem. As argued above, simple countermeasures that are likely within reach of rogue adversaries may degrade ballistic missile defense significantly, as may limitations in geographical coverage and interceptor inventory. The second risk is that pursuing the point solution could soak up available resources and diplomatic capital, at the expense of long-term U.S. missile defense needs. This is especially the case if the point solution's contribution to the general solution is very limited.

[18] Of course, there are also countermeasures to boost-phase intercept, including fast-burn boosters to shorten intercept timelines, spinning the booster to spread laser energy over a wider area on the target, and reflective or ablative coatings on the missile body, to name a few.

Aligning the point solution with the general solution can help mitigate both these risks. By improving the ability to handle threats that are more sophisticated, somewhat larger, and more dispersed geographically, the United States could field a more robust initial defense. Interim enhancements along these three axes would almost surely require additional resources and time. However, they would increase the confidence of defeating the near-term threat while laying the groundwork for a viable long-term solution.

To begin with, it should be possible to improve the robustness of the point solution against more sophisticated threats. One practical way to do this would be to deploy more quickly the discrimination upgrades envisioned for the C2 capability. Another would be to intensify BMC3 development. Among other things, this could enhance the contribution of the early warning and ground-based radars. A more ambitious possibility would be to speed deployment of SBIRS Low to enable infrared discrimination of threats in midcourse, prior to the intercept endgame.

A larger interceptor inventory would hedge both against rogues that accelerate their missile development rate and against the uncertainty of our intelligence estimates. How many interceptors to deploy initially is difficult to determine definitively. The debate should be informed, however, by a detailed analysis covering the technical, budgetary, diplomatic, and strategic issues that bear on the question. In due course, a force of, say, 150–200 interceptors could be justified. But given the sensitivity to Russian and Chinese interpretations of U.S. missile defense (see "Managing the ABM Treaty, Russia, China, and Offensive Forces") and the relative ease with which more interceptors could presumably be fielded, it may be adequate and more prudent to limit the inventory to 100 or so for now.[19]

Finally, deploying additional X-band radars for precision tracking and discrimination could relax the interceptor engagement timelines in certain scenarios, potentially improving overall system performance and geographical coverage. Radar sites covering the Atlantic and Pacific coasts are possible.[20] In deploying additional radars, however, we must recognize that the critical factor in a rapidly expandable ABM system is the sensors. With sensors in place, increasing interceptor inventories translates more directly into expanded capability. This fact will not be lost on Russia or China, and so this issue must be managed accordingly.

The "interim solution" outlined above entails a near-term focus not on Point A but on a subvolume in the space of plausible threats (see the lower-front-left box in Figure 3). As illustrated below, this volume is a subset of the larger space covered by the general solution and begins to address the evolution of the threat on all three axes.

Although more costly than the point solution, there is less risk that such an interim solution will infringe on the deployment of a more capable solution (e.g., C1 cost and schedule overruns delaying C2). It may also take more time to deploy the interim solution than the point solution. But once done, there is more assurance that the solution will meet the threat. In addition, the interim solution would "raise the bar" for adversaries. For example, the larger interceptor inventory could handle a larger threat. The capability to defeat simple countermeasures forces adversaries to develop more sophisticated ones. These countermeasures would likely require more expense and are probably beyond the reach of typical rogue states, at least for the foreseeable future. Conversely, having limited, or possibly zero, capability against even simple countermeasures invites adversaries to deploy them.[21]

Thus, enhancing the point solution along the three axes of the general problem mitigates both key risks identified above. The point solution becomes more robust, and the steps to make it so are investments in, not diversions from, the general solution.

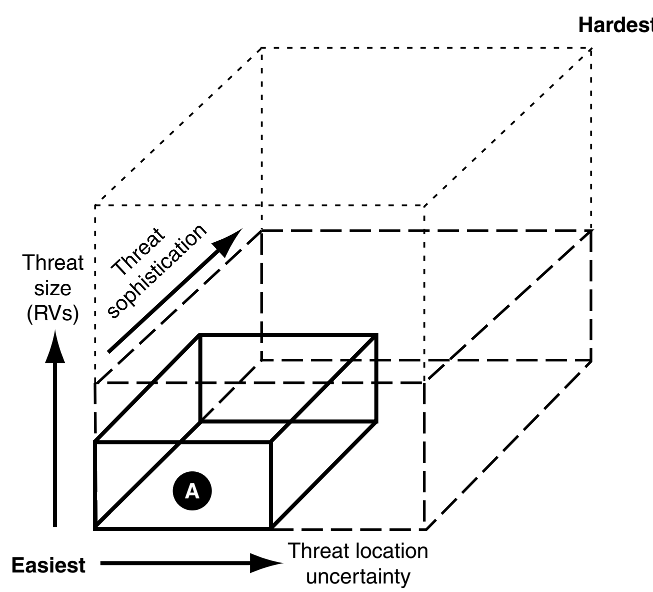

Figure 3—Interim Solution

[19]One hundred interceptors is below the threshold at which future Russian and Chinese strategic nuclear forces could be threatened (Wilkening, 1998). But again, detailed analysis should inform the setting of the initial inventory level.

[20]One possible C2 architecture envisions an Alaska weapon basing accompanied by X-band radars at Shemya (the Aleutians), Clear (Alaska), Fylingdales (Great Britain), and Thule (Greenland).

[21]Garwin and Bethe (1968) made a similar argument more than 30 years ago in the context of the policy debate surrounding the Sentinel system.

MANAGING THE ABM TREATY, RUSSIA, CHINA, AND OFFENSIVE FORCES

Russia and the Treaty

There is no escaping the fact that Russia will oppose, resist, and react to any U.S. attempt to alter the ABM Treaty to permit defense of the United States proper. The approach suggested here would not be welcomed in Moscow. However, the Russian reaction could be mitigated by a skillful American strategy.

Table 4 illustrates that even the "interim solution" described in the previous section would require greater modification of the ABM Treaty than would the current DoD point solution. Beyond that, our illustrative system of systems (the general solution) would require, among other things, lifting the ban on mobile and sea-based systems and either lifting or easing the ban on space-based components. These changes would be harder to negotiate and would unquestionably weaken the ABM Treaty. However, by trying to minimize treaty changes, the United States would either leave itself with inadequate ballistic missile defense or be required to slice away at the treaty's restrictions salami-style, with protracted and perhaps worse cumulative effects on U.S.-Russian relations.

Whether the United States should soon propose—insist on?—*all* the changes it might require to field adequate ballistic missile defense is a tactical call, which we cannot make. However, we would note that the Russians, in their current state of mind, might take a hostile view toward *any* proposed modification. Many in the Duma are convinced that the United States wants to strip away every vestige of Russian power, and they will exploit for their political purposes any U.S. attempt to loosen the constraints of the ABM Treaty. Already, some have seized on the mere possibility of U.S. NMD as justification not to ratify START II. Thus, the Russians' reaction to an inadequate modification of the treaty could be nearly as bad as the reaction to an adequate modification.

Whatever the best U.S. negotiating tactic, it is imperative to understand up front what, if any, ballistic missile defense arms control regime is consistent with an adequate general solution for the United States. We are not suggesting that there would be no acceptable, even useful, restrictions compatible with a U.S. system of systems. However, as noted, many of the current treaty's key restrictions shut off avenues to effective defense. If we are correct that solving a time-bound point problem but ignoring the general problem makes no sense, the United States must weigh at the outset how far it is prepared to go in dismantling ABM arms control.

The ABM Treaty is no longer an appropriate cornerstone for U.S.-Russian security relations, and continuing to give it such exalted status is counterproductive. Trying to adjust fig leaves around the treaty will harm, not help, Russian-American relations. We need new cornerstones based on new realities and serving the strategic interests of both countries.

Defenses and Strategic Offensive Forces

Because the United States is in the best position to field effective ballistic missile defense and, being every rogue's nemesis, has the greatest need, it thus has the least to lose and most to gain from the loosening of missile defense arms control. At the same time, the United States must anticipate consequences of reopening the ABM Treaty other than facing adversary missile defenses. It is precisely because the Russians cannot build an effective missile defense system that their response to paring back

Table 4
Possible Modifications of the ABM Treaty

Constraint	Reference	Point Solution	Interim Solution	General Solution
U.S. site located at Grand Forks, North Dakota	Common Understanding	✔	✔	✔
No ABM defense of the country's territory	Article I	✔	✔	✔
100 ABM interceptors and launchers at each ABM site, collocated with ABM radars	Article III		✔	✔
No use of other systems capable of substituting for ABM interceptors, launchers, or radars without agreement of the parties	Agreed Statement D		✔	✔
No capability to counter strategic ballistic missile except as allowed under Article III	Article VI		✔	✔
Only one site deployed at any given time	Protocol			✔
No development, testing, or deployment of sea-based, air-based, space-based, or mobile land-based ABM interceptors, launchers, or radars	Article V			✔
No TMD testing against targets moving greater than 5 km/s	1997 Joint Statement			✔
No TMD testing against ballistic missiles with ranges greater than 3,500 km	1997 Joint Statement			✔

NOTE: ✔ Indicates treaty modifications could be required.

or ending the ABM Treaty—beyond complaining about it—would likely be in offensive nuclear forces. A threat by the Russians to respond by expanding their offensive arsenal is not credible, because they cannot maintain much more than a 1,000-deliverable-weapon strategic force for very long in any case. But a Russian threat to reclaim their right to deploy multiple independently targetable reentry vehicles (MIRVs) on land-based ICBMs (banned under START II) would be credible. It is a practical and economical path Russia could take to bolster its ability to penetrate U.S. ballistic missile defense and thus retain a credible deterrent. Indeed, even some Russian "liberals" have come to view START II's ban on MIRVed ICBMs as inequitable and disadvantageous for Russia.

Such a Russian course of action would be unfortunate but not so bad as to cause the United States instead to leave itself open to rogue ballistic missile attack. After all, the Russians cannot maintain numerical parity with U.S. strategic offensive forces except with further deep START reductions. Without further mutual reductions, the Russians could find themselves with a force of 1,000 or so weapons (MIRVed or not) facing a qualitatively and quantitatively superior U.S. offensive force *and* U.S. missile defense. In such circumstances, a Russian MIRVed ICBM force would not be as threatening or destabilizing as we feared it was when a Soviet first-strike capability could not be excluded.

If the Russians know the United States intends to erect ballistic missile defenses, they would be wiser to press ahead with START than to stall it. Yet this is for them to decide. Moreover, if the United States allows itself to be coerced by a Russian threat to hold START hostage, the U.S. ability to defend against rogues will itself become a hostage—to Russian manipulation and irrationality.

This is not to suggest that a U.S. missile defense system of systems should or could deny the Russians a credible second-strike deterrent, especially if U.S. forces are further reduced through START (Wilkening, 1998). The United States should be willing to show, patiently and in detail, that its system of systems is not designed or sized against the Russian deterrent—indeed, that it is constrained to respect that deterrent. While this does not preclude a U.S. breakout by developing its system of systems or improving kill probabilities, at least it would display the right intent and, one would hope, help convince the Russians not to scuttle START.

Finally, the United States needs to consider the appropriate level for its own strategic offensive forces in a world in which ABM restrictions are significantly eased. Again, determining the precise level should be informed by detailed analysis. If it thought other powers were in a position to build effective defenses in the foreseeable future, the United States might need to maintain a larger force—say, upward of 2,000 weapons. However, because this is not the case, the United States could consider negotiated or unilateral reductions below that level. This would be more than adequate in today's world, while also showing both the Russians and the Chinese that the United States was not aiming to create a dominating, counterforce-cum-defense, first-strike capability against either.

China

Compared to Russia, managing the Chinese dimension is at once easier, because no negotiation is required, and harder, because China's strategic offensive missile force is small but growing, while Russia's is large but shrinking. The current size of China's strategic force is a particular complication: An effective antirogue U.S. ballistic missile defense system of systems could reduce Chinese confidence in its second-strike capability. It would present the added problem, in Chinese eyes, of offering not only layered defense of U.S. territory but extended defense of U.S. friends and allies, notably Taiwan and Japan. However well the United States manages the Russians and the ABM Treaty, the potential exists for a costly misunderstanding with China.

The Chinese would seemingly react less sharply to a U.S. decision to defend itself than to a plan to defend Taiwan from ballistic missile attack. They have lived for decades in the knowledge that they do not have an assured second-strike capability against the United States, and rectifying this has not appeared to be a high priority. However, a U.S. ballistic missile defense umbrella over Taiwan would be viewed as striking at the heart of China's sovereignty and its ability to coerce the Taiwanese. Independent of U.S.-Taiwanese missile defense collaboration, there is no question that the system of systems we have described would inherently provide some capability to defend Taiwan from Chinese missile attack. Both for this reason and to avoid a strategic arms race with China, it is important to maintain a stable overall Sino-American relationship, manage skillfully the explosive issue of Taiwan, and begin a dialogue on strategic nuclear issues.

In this context, the United States should make the same effort with China as with Russia to show that the Chinese deterrent force is not the target of U.S. missile defense. However, based on the numbers alone, the Chinese could be harder to convince. Therefore, the United States must be prepared for China to expand its strategic offensive arsenal, especially in weapons capable of reaching the United States. Perhaps China will expand these capabilities anyway. However, the United States should not be surprised or incensed to discover that the Chinese are increasing their strategic arms when the U.S. ballistic missile defense system has given them further reason to do so. We believe that even a general solution to the rogue ballistic missile threat should not seek to keep pace with future—and likely—growth in Chinese offensive capabilities. Even a larger Chinese strategic force can be held in check by the vastly superior U.S. strategic force.

CONCLUSIONS

1. Ballistic missiles are one of a number of vehicles for delivering WMD. In many situations, they can be the vehicles of choice. Without the means to deny rogues the ability to threaten U.S. forces, allies, other interests, and homeland with such missiles, they will be able, or at least tempted, to weaken the ability and the will of the United States to project power in order to protect its interests and meet its responsibilities. Effective ballistic missile defense is, therefore, strategically important for the United States.

2. However, current U.S. plans for ballistic missile defense are inadequate in three respects:

   a. The C1 capability is not robust enough to justify confidence that it can counter the particular threat for which it is designed.

   b. Neither is the C1 capability an adequate platform on which to base a general solution to the evolving, long-term threat.

   c. Modifying the ABM Treaty only to permit the C1 capability might not permit adequate defense against even the near-term threat and would restrict efforts to address the general problem.

3. The general problem could involve threats that are more sophisticated, have greater location uncertainty, and are larger than the threat the C1 capability is intended to counter. It is therefore important to envision a general solution that addresses these dimensions, is integrated, and can be adapted as threats evolve.

4. Rather than thinking in terms of "TMD" and "NMD," the general solution should be a "system of systems" based on three synergistic layers:

   a. Fixed U.S.-based defense, to ensure protection of the highest-value target—the homeland—even without strategic warning.

   b. At the other end, deployable (with strategic warning) boost-phase intercept, to kill threatening ballistic missiles, of most any range, when they are first detected and before most countermeasures can be employed.

   c. Bridging the two ends, a flexible, deployable element capable, with modest warning, of contributing at either end and of intercepting ballistic missiles in early midcourse.

5. The elements of this system of systems, and actual missile defense operations, would be integrated by a common, mainly space-based sensor and BMC3 system.

6. Building blocks for these four elements might be (1) C1/C2, (2) the ABL, (3) NTW, and (4) SBIRS High and Low.

7. With such a general solution in mind, enhancements to the current U.S. program should be analyzed in detail. One option is to consider the following course:

   a. Develop an interim solution as soon as possible that, compared to C1, could handle threats that are more sophisticated, somewhat larger, and more dispersed geographically. This might involve upgrading the target discrimination capability, improving BMC3, increasing the interceptor inventory moderately, and deploying additional X-band radars. Speeding deployment of SBIRS Low might also be considered. Such enhancements would align our defense capability with the general solution and make it more robust in the near term.

   b. Invest, in parallel, in a versatile and robust early midcourse component, possibly based upon NTW.

   c. Intensify development of boost-phase intercept.

8. The impact of the general solution on the ABM Treaty should be understood now. An effective and adaptable general solution would require the relaxation of many of the treaty's restrictions. The U.S. negotiating position regarding the ABM Treaty should be informed by the general and interim solutions.

9. Russia and China should each be told, in effect, that the U.S. ballistic missile defense system of systems is not intended to thwart their strategic deterrent capabilities.

10. The United States needs to determine the appropriate level for its strategic offensive forces in a world in which ABM restrictions have been eased significantly. The precise level should be informed by analysis, with a view toward offensive adequacy and convincing Russia and China that deployment of missile defense does not mean that the United States seeks strategic nuclear domination.

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