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Working Paper

How Much Ballistic Missile Defense Is Too Much?

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October 1998

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The Center is grateful to the Carnegie Corporation of New York for supporting this research.

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Abstract

This paper derives the levels of national and theater missile defense that might pose a realistic threat to the strategic nuclear forces of the major nuclear powers, thereby undermining strategic stability. Changing one's strategic targeting doctrine to concentrate on targets located within a fraction of the defender's national territory may ameliorate this threat, at some cost to the effectiveness of one's deterrent. Deploying decoys and other penetration aids is the preferred long-term solution. With respect to national missile defense, levels as high as between 100–300 U.S. national missile defense (NMD) interceptors might be acceptable to Russia, assuming their future strategic nuclear force contains between 1,300–2,400 warheads, although levels between 100–200 NMD interceptors would be required to provide much comfort to France and Great Britain if such defenses were deployed by Russia. However, NMD systems with as few as 100 interceptors would likely pose a threat to the future Chinese strategic nuclear force. Effective U.S. upper-tier theater missile defense (TMD) systems may appear threatening to Russia, if they are deployed around the United States, but only if these interceptors can conduct engagements using accurate midcourse track data from space-based sensors such as SBIRS-LEO. If so, the current THAAD program (1,233 interceptors) would appear threatening unless Russia concentrates its retaliatory strike against targets located within 10–30 percent of the United States. To reduce Russian concern with TMD breakout, the United States should consider reciprocal monitoring of each others TMD garrisons and TMD production sites. The hypothetical impact of a Russian upper-tier TMD system on France and Great Britain may also be manageable, assuming Russia deploys no more than between 500–1,000 THAAD-like interceptors, because their targeting doctrines involve threatening targets located within only a few defended areas. Again, the impact on China would be greater. Finally, the most attractive TMD systems may be airborne boost-phase theater missile defenses (i.e., the Airborne Interceptor or Airborne Laser programs). Although these systems might have the capability to shoot down strategic missiles if they are within range, they do not pose a realistic threat to the strategic nuclear forces of any of the five major nuclear powers for operational reasons.

Acknowledgments

I wish to thank George Bunn, Charles Glaser, Steve Fetter, Lt. Gen. Glenn Kent (USAF ret.), Michael May, and Ted Postol for sharing their insights on ballistic missile defense and for providing valuable critiques of various aspects of this work. I also wish to thank the Center for International Security and Cooperation at Stanford University and the Carnegie Corporation, without whose support this work would not have been possible.

The views expressed here are solely the author's and do not reflect those of the Center, the Carnegie Corporation, or any of the Center's other sponsors.

How Much Ballistic Missile Defense Is Too Much?

Introduction

Debates about ballistic missile defense (BMD) frequently revolve around the political/military objectives that defenses help achieve or undermine.[1] A common theme, particularly in American debates about ballistic missile defense, is that defenses, if deployed in sufficient numbers, will undermine strategic stability, thereby poisoning relations between states, possibly stimulating offense–defense arms races, and potentially undermining crisis stability. Although the argument frequently is made for rhetorical purposes, few attempts have been made to quantify the level of defense that might cause these effects. Given that political pressures are inexorably moving the United States toward deployment, understanding the level of defense that might undermine strategic stability is of more than academic interest.

Put another way, there is a tension between the requirements for "How much ballistic missile defense is enough?" and "How much ballistic missile defense is too much?" Specifically, can the United States deploy national and theater missile defenses that meet criteria for the former without simultaneously violating the latter? For example, does the level of national missile defense (NMD) required to protect the United States from small accidental or unauthorized ballistic missile attacks, or the level of theater missile defense (TMD) required to defend U.S. troops and allies from theater-range ballistic missiles, conflict

[1] For articles on the political/military impact of ballistic missile defense see Charles Glaser, "Why Even Good Defenses May Be Bad," *International Security*, Fall 1984, pp. 92–123, and "Do We Want the Missile Defenses We Can Build?" *International Security*, Summer 1985, pp. 25–57; and Keith Payne and Colin Gray, "Nuclear Policy and the Defensive Transition," *Foreign Affairs*, Spring 1984. For more recent articles see Lisbeth Gronlund, George Lewis, Theodore Postol, and David Wright, "Highly Capable Theater Missile Defenses and the ABM Treaty," *Arms Control Today*, April 1994, pp. 3–8; Spurgeon Keeny, Jr., "The Theater Missile Defense Threat to U.S. Security," *Arms Control Today*, September 1994, pp. 3–7; Keith Payne, "Post–Cold War Deterrence and Missile Defense," *Orbis*, Spring 1995, pp. 201–223; Curt Weldon, "Why We Must Act at Once," *Orbis*, Winter 1996, pp. 63–70; and Henry Cooper, "To Build an Affordable Shield," *Orbis*, Winter 1996, pp. 85–100.

with the requirements for strategic stability, particularly as the level of offensive nuclear forces is reduced to START II levels and below?

This paper addresses these questions. It is divided into four sections. The introduction discusses post–Cold War U.S. security objectives appropriate for determining how much ballistic missile defense is too much. The second section addresses the question of how much national missile defense is too much. The third section addresses the same question for theater missile defense. And, the last section provides some concluding observations.

Objectives for Determining How Much Ballistic Missile Defense Is Too Much

A number of political objectives, in principle, can be used to determine how much national or theater missile defense is too much. The "influence diagram" in Figure 1 tries to capture most of these. Among them are the goal of U.S. and Russian strategic nuclear force reductions to START II levels and beyond—although there are reasons other than U.S. BMD deployments that may lead Russia to not ratify START II, notably NATO expansion and the Russian belief that the treaty itself is inequitable.[2] In addition, Russia's increased emphasis on nuclear weapons to compensate for relatively weak conventional forces suggests that reductions below START III levels (i.e., 2,000–2,500 strategic nuclear weapons) may not be forthcoming regardless of U.S. BMD programs.

U.S. BMD deployments could also lead to Russian BMD deployments at some future date which, in turn, could provoke a French, British, and/or U.S. response, e.g., the deployment of advanced penetration aids as occurred with the French and British SLBM programs in the late 1970s and early 1980s to counter improvements in the Soviet ABM system around Moscow. This concern must be tempered by the fact that Russia, with its current economic problems, may not deploy comparable BMD systems for many years to come and by the fact that Russian ballistic missile defenses, if they were deployed, are less threatening to the West in the post–Cold War era.

Of greater interest is the Chinese reaction to U.S., or Russian, BMD systems. A thorough discussion of possible Chinese reactions is beyond the scope of this paper.[3] Obviously, their reaction will depend on the size and location of these defenses. For example, a thin U.S. national missile defense could have a substantial impact on the current Chinese retaliatory

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[2] Given the impending obsolescence of Russia's strategic nuclear force and the economic constraints on future force modernization, it is also quite possible that Russia will ratify the START II Treaty despite concerns with U.S. BMD programs.

[3] For related articles see Clay Moltz, "Missile Proliferation in East Asia: Arms Control vs. TMD Responses," *The Nonproliferation Review*, The Monterey Institute of International Studies, Vol. 4, No. 3 (Spring–Summer 1997), Monterey, CA, pp. 63–71; Stephen A. Cambone, "The United States and Theatre Missile Defense in North-east Asia," *Survival* (London: International Institute for Strategic Studies, Autumn 1997), pp. 66–84; and Michael Nacht and Tom Woodrow, "Session 6: Nuclear Issues," in *Strategic Trends in China*, Hans Binnendijk and Ronald N. Montaperto, eds., Institute for National Strategic Studies, National Defense University, U.S. Government Printing Office, Washington, D.C., 1998.

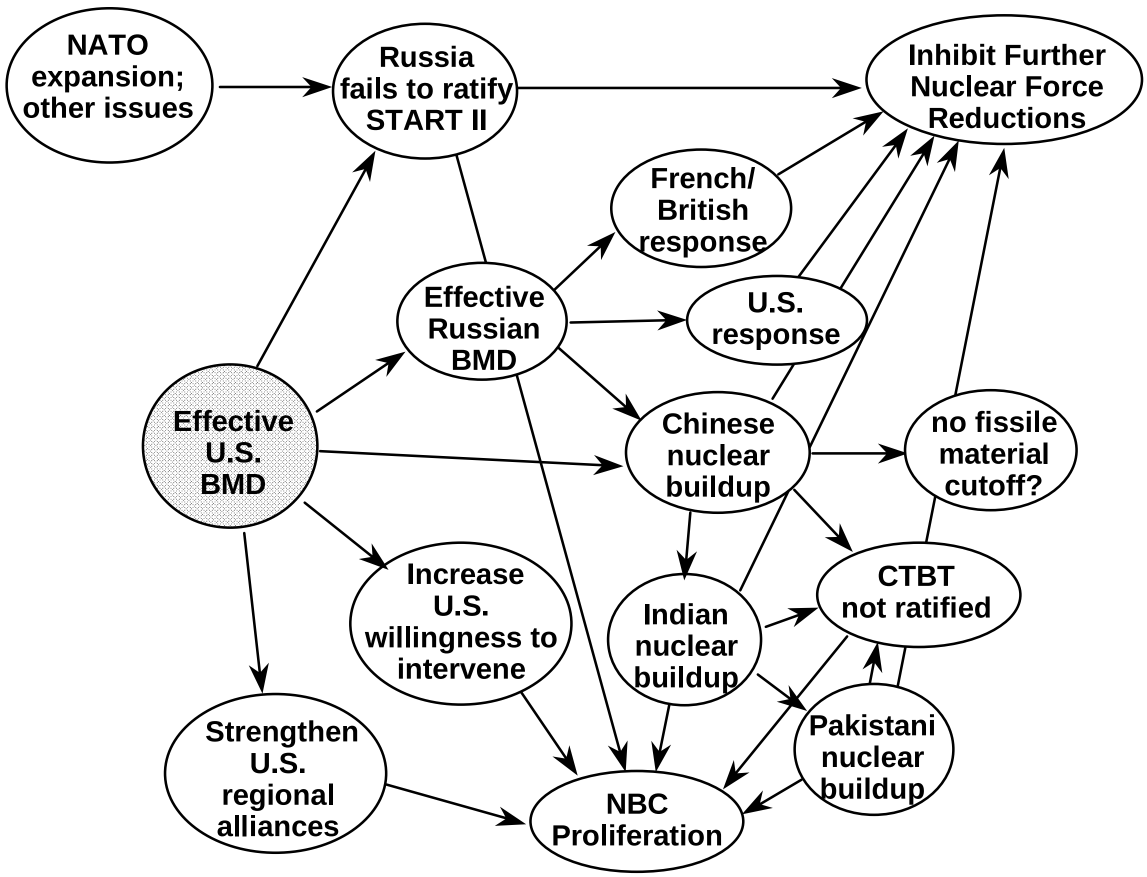

Fig. 1 - U.S. Ballistic Missile Defense Influence Diagram

capability because their current long-range missile force is quite small (reportedly 18 DF-5/5A ICBMs).[4] However, this will be less true for the Chinese strategic arsenal in 2010–2015 because it is expected to increase in size and improve in survivability (see the appendix). Moreover, a U.S.-Chinese offense–defense arms race is not axiomatic in the case of a thin U.S. national missile defense, however logical it may seem.[5] The impact of a

[4] See Bill Gertz, "China targets nukes at U.S.," *The Washington Times*, May 1, 1998, p. 1.

[5] In the past, China did not react strongly to U.S. capabilities that undermined its secure second strike. In particular, its reaction was quite desultory when, in the late 1960s, the United States claimed its Safeguard/Sentinel ABM system was being designed with the Chinese threat in mind. The same can be said with respect to the Moscow ABM system. Penetration aids and MIRVs were discussed, and some penetration aids may have been deployed on the DF-5 ICBM, but China has yet to deploy an effective MIRVed ICBM or SLBM. China also reacted quite slowly to the vulnerability of its strategic nuclear force with respect to preemptive U.S. counterforce attacks. China never developed the warning network and command and control system required to launch its missiles on warning. Efforts were made to reduce the reaction time of its transportable DF-3 missiles so they could be launched in two to three hours instead of four hours and DF-5 missiles were based in hardened silos surrounded by numerous silo decoys. However, these efforts did not

Russian NMD system on China's retaliatory capability will be less pronounced because a modest number of intermediate-range ballistic missiles can strike the Russian homeland in addition to Chinese ICBMs and SLBMs.

China's greatest concern likely will be U.S. TMD research and development cooperation with, or actual TMD deployments to, states around its periphery. TMD assistance to Taiwan would be viewed as quite threatening, partly because improvements in Taiwan's military capabilities could encourage further moves toward independence and partly because TMD systems would symbolically, if not actually, blunt one of the few military instruments Beijing has to pressure Taiwan, namely conventionally-armed ballistic missiles—recall the March 1996 M-9 missile firings toward Taiwan to intimidate that country on the eve of its national elections. TMD cooperation or deployments to Japan might also appear threatening because many Chinese leaders still view Japan as an aggressive militaristic state. For example, Japan's large stock of plutonium for its civilian nuclear power industry is believed to provide a latent nuclear weapons capability. This capability could appear more threatening if Japan had defenses to protect its territory from China's nuclear missiles. TMD deployments to South Korea probably would not upset the U.S.-Chinese relationship because of the clear need to protect South Korea from North Korean ballistic missiles. This, of course, could change after Korean unification. Finally, U.S. naval TMD systems (e.g., the Navy Theater-Wide defense) likely will appear threatening to Chinese leaders because their mobility implies they can defend Taiwan, Japan, or other territories around the Chinese periphery.

If U.S. BMD deployments spur Chinese nuclear force modernization, this could lead China to reject ratification of the Comprehensive Test Ban Treaty (CTBT), possibly make China less willing to cut off fissile material production, and reduce China's interest in future arms control agreements that limit the size of its nuclear arsenal. In the past, the Chinese response to U.S. and Russian ABM systems was to develop penetration aids for its long-range missiles.[6] Developing MIRVs also was considered but was delayed until quite recently due to the lack of a lightweight warhead and technical hurdles associated with the post-boost vehicle.[7] Both of these options are likely in the future if U.S. or Russian BMD systems are deployed.

Whether or not the United States should deploy a national missile defense specifically to defend against Chinese ICBMs and SLBMs is, of course, not a question of whether U.S.

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substantially improve the survival of the Chinese force to a dedicated U.S. counterforce attack. More recently China has developed solid-fuel mobile IRBMs and mobile ICBMs. These systems will improve Chinese force survival after they enter the force in substantial numbers. See John Wilson Lewis and Hua Di, "China's Ballistic Missile Programs: Technologies, Strategies, Goals," *International Security*, Vol. 17, No. 2 (Fall 1992), pp. 21–26. One should note, however, that asserting that China was less concerned about U.S. damage-limiting capabilities in the past does not necessarily imply that it will be indifferent to U.S. defenses in the future, especially if it sees the United States as its principal rival.

[6] Ibid., pp. 21–22.

[7] See James A. Lamson and Wyn Q. Bowen, "'One Arrow, three stars': China's MIRV program, Part I," *Jane's Intelligence Review*, May 1997, pp. 216–218; and James A. Lamson and Wyn Q. Bowen, "'One Arrow, three stars': China's MIRV program, Part II" *Jane's Intelligence Review*, June 1997, pp. 266–269.

leaders prefer to remain vulnerable to Beijing out of deference to a strategy of mutual assured destruction, but rather whether the United States can achieve an effective defense of its territory given that an offense–defense arms race may ensue as China attempts to reestablish the effectiveness of its deterrent. Since Chinese missile technology is fairly advanced and China will likely have the GNP to engage in a strategic competition of some intensity, the prospect for achieving an effective defense against Chinese missile threats is not high. Moreover, the U.S. nuclear deterrent force should be quite effective for dissuading China from threatening the United States or its allies with nuclear attack—especially since the United States has escalation dominance with respect to China. However, this is not to say the United States should avoid BMD deployments that marginally undermine the Chinese ballistic missile force if other threats warrant such a defense.

Ultimately, U.S. BMD programs might inhibit further U.S.-Russian nuclear force reductions or Chinese willingness to join such arms control efforts. Similarly, Russian BMD deployments could have an impact on the French, British, and Chinese willingness to join the nuclear arms reduction process. The question is whether these effects will actually materialize and, if so, at what levels of defense.

U.S. BMD deployments could also undermine U.S. nonproliferation objectives. For example, Chinese nuclear force modernization could, in turn, lead to an Indian nuclear response, which subsequently could lead to a Pakistani nuclear response. Chinese failure to ratify the CTBT, or Indian and Pakistani nuclear buildups, would have a negative impact on the Non-Proliferation Treaty (NPT) regime—although the magnitude of this impact is debatable. In addition, U.S., Russian, French, British, or Chinese nuclear force modernization in response to another state's ballistic missile defense could undermine the NPT regime by creating the impression that the nuclear powers are not abiding by their Article VI obligations to negotiate in good faith toward the eventual elimination of nuclear weapons.

This said, it is difficult to assess the extent to which U.S. BMD programs might actually undermine U.S. nonproliferation goals. For example, China is modernizing its strategic nuclear forces, albeit slowly, for reasons independent of U.S. BMD programs. The CTBT may not enter into force for a host of reasons, not the least of which is that this requires ratification by all 44 states that currently possess either nuclear power or nuclear research reactors—several of which are hostile to CTBT ratification. Finally, the India–Pakistan nuclear competition is driven largely by regional security concerns and domestic politics, not U.S. BMD programs, as the recent nuclear tests by these countries demonstrate. Recall that the argument was made that U.S. TMD programs would undermine efforts to extend the Non-Proliferation Treaty indefinitely in March 1995 but the effect never materialized or, if it occurred, the impact was slight.

Perhaps the most direct influence that U.S. BMD programs have in subverting U.S. nonproliferation goals is the fact that the very purpose of theater, if not national, ballistic missile defense is to make U.S. regional intervention possible by strengthening regional alliances and by reducing the risks to the United States of regional intervention. To the extent the United States is more willing to intervene in regional conflicts because it has defenses to protect its forces and allies, regional states have a greater incentive to acquire nuclear, biological, or chemical weapons to deter U.S. intervention, although if BMD systems are effective they will choose delivery means other than ballistic missiles. This tension is fundamental. It is not a reason to avoid ballistic missile defense. One simply should be realistic about the fact that any military capability that makes U.S. intervention more likely presents a security problem for U.S. adversaries and, hence, will increase their interest in weapons of mass destruction—insofar as they are motivated to acquire these weapons for reasons of security.[8]

The problem with all of the above arguments is that it is difficult to determine which ones are valid from among the logical possibilities, that is, to determine the sign and magnitude of the effects portrayed in Figure 1. Having said this, the effect that seems most salient is the risk that national or theater ballistic missile defenses might upset strategic stability between the major nuclear powers, in particular Russia and the United States. This clearly was a concern during the Cold War, culminating in the ratification of the ABM Treaty. Recently, presidents Clinton and Yeltsin reaffirmed the importance of maintaining strategic stability when they signed the ABM Treaty Demarcation Agreements on September 26, 1997, wherein TMD systems are allowed under the ABM Treaty so long as they do "not pose a realistic threat to the strategic nuclear forces of another Party and will not be tested to give such systems that capability."[9] Maintaining strategic stability with respect to smaller powers that acquire ballistic missiles armed with weapons of mass destruction in the future is much less important.[10]

Maintaining strategic stability is still important for the simple reason that, although intentional nuclear attacks between the major nuclear powers are more remote now than at any time in the past 50 years, large nuclear arsenals will continue to exist into the indefinite future. Moreover, there is little evidence that defenses can replace nuclear deterrence for protecting the United States, or any major power, from large nuclear attacks. Building an effective defense against hundreds or thousands of ballistic missile warheads delivered by an

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[8]This is similar to the lesson Indian Army general Sundarji drew from the 1991 Gulf War, namely, that states should acquire nuclear weapons before confronting the United States. See George Quester and Victor Utgoff, "No-First-Use and Non-proliferation: Redefining Extended Deterrence," *The Washington Quarterly*, Vol. 17(2), Spring 1994, p. 107.

[9] See U.S. Arms Control and Disarmament Agency (ACDA), *Second Agreed Statement Relating to the Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems of May 26, 1972* (Washington, DC: ACDA, September 26, 1997).

[10] First, defenses may be effective against an adversary with a limited arsenal and less sophisticated countermeasures. Second, maintaining stability is of less concern because upsetting political relations with "rogue" states is less important, stimulating an arms race with less-developed states may not be economically disastrous for the United States (though it could be more costly than is warranted by the interests the United States is trying to protect), and the incentive "rogue" states have to launch preemptive attacks in a crisis is not strong because, by so doing, they cannot improve their chances for survival. In the U.S.-Russian context, first-strike instability is driven less by a desire simply to "use one's weapons before losing them," and more out of the possibility that a preemptive strike may destroy a large fraction of the opponent's weapons, thereby increasing the chance that one's country will survive the ensuing war.

adversary that can deploy decoys and other penetration aids, substantially increase the size of its ballistic missile arsenal, circumvent the defense using different delivery means, and possibly suppress the defense is simply too great a task at the current time. Therefore, as long as the major powers rely on nuclear deterrence for their security, maintaining stability will be important.

Consequently, ballistic missile defenses are deemed to be "too much" if they pose a realistic threat to U.S. or Russian strategic nuclear forces. A thin defense might also be considered threatening if it provides the base for a more robust defense. Finally, a defense that poses a realistic threat to British, French, or Chinese strategic nuclear forces could also be considered to be "too much."

Determining the level of defense that poses a threat depends, among other things, on the number of arriving weapons that are sufficient for deterrence from the attacker's perspective. Moreover, the requirements for sufficiency vary with time, the character of the opponent, the interests being threatened, and the conflict scenario. This is one of the main subjective factors that determines whether a given level of defense poses a realistic threat to an opponent's strategic forces. Thus, if the attacker believes that holding only a few targets at risk is sufficient for deterrence (e.g., the nation's capital), ballistic missile defenses will appear less threatening because the attacker can concentrate its retaliatory strike to saturate the defense. On the other hand, if the attacker believes he must hold at risk a wide range of targets, potentially located in many defended areas, the more threatening even limited ballistic missile defenses will appear.

The criterion used to determine when a defense poses a "realistic threat" is also not obvious. One approach would be to state that ballistic missile defenses should pose no greater threat than that allowed by the ABM Treaty at the time the treaty was signed. The original ABM Treaty allowed a maximum intercept potential of 200 warheads (later reduced to 100 warheads by the 1976 ABM Treaty Protocol), thereby providing a hypothetical ability to intercept approximately 10 percent of the 1972 Soviet strategic ballistic missile force on generated alert and between 20 to 30 percent of its missile warheads on day-to-day alert—depending on the assumptions one makes regarding the survival of Soviet submarines and silo-based ICBMs after a U.S. surprise attack. Given that tensions between the major nuclear powers today are much lower than the tensions between the United States and the former Soviet Union in 1972, this criterion seems too restrictive.

This analysis assumes that ballistic missile defenses begin to pose a "realistic threat" if they can block 20 percent of the opponent's ballistic missile retaliation, i.e., twice the level allowed by the original ABM Treaty. The degradation of the overall retaliatory capability is less if bomber weapons are included. Twenty percent attrition is enough to complicate attack planning and to raise concerns about the future viability of one's ballistic missile force if defense deployments continue, yet by no means represents a significant damage-limiting capability. After all, problems with force survival and system reliability already reduce the size of a country's retaliatory capability relative to the deployed force by at least 20 percent on generated alert. Therefore, U.S. national and theater missile defenses are deemed be to "too much" if they reduce a major nuclear power's ballistic missile retaliation by 20 percent.

How Much National Missile Defense Is Too Much?

The extent to which a U.S. national missile defense can intercept an attack depends on the size of the defense coverage (or "footprint") associated with each NMD site, the number and effectiveness of the NMD interceptors, and the size and character of the offensive attack.[11] With respect to the size of future hypothetical attacks, Russia is assumed to have a strategic force under START II (or START III) with between 1,320 to 2,430 total strategic nuclear warheads in the 2010–2015 time frame (see the appendix). China is assumed to have a strategic nuclear force with 86–190 ballistic missile warheads capable of reaching the United States between 2010–2015 (see the appendix).

In terms of coverage, two NMD sites can cover the continental United States (i.e., the 48 contiguous states) with a barrage firing doctrine for attacks coming from all azimuths (as would approximately be the case if Russia deployed SLBMs off the east and west coasts of the United States)—assuming NMD interceptor flyout speeds above 6.5 km/sec and sensor architectures that include one of the following options currently under consideration: (1) placing additional ground-based tracking radars around the periphery of the United States, (2) placing tracking radars around the U.S. periphery and upgrading existing ballistic missile early-warning radars located in England and Greenland, or (3) deploying space-based missile acquisition and tracking sensors such as the Space-Based Infrared System–Low Earth Orbit (SBIRS-LEO) satellite. Four to nine sites would be required for a shoot-look-shoot firing doctrine. If the attack comes only from a northerly direction, i.e., Russian ICBMs and SLBMs launched from their bastions or Chinese ICBMs, then only one site is required for barrage coverage of the 48 states and two sites for shoot-look-shoot coverage, assuming one of the latter two sensor architecture options.[12]

Figure 2 illustrates the Russian retaliatory capability for a 1,850-warhead Russian force after absorbing a hypothetical U.S. counterforce first strike on generated alert, as a function of the number of NMD interceptors deployed at a single site within the United States. The NMD interceptors are fired in a barrage and are assumed to have a single-shot probability of kill (SSPK) equal to 0.9 from a Russian worst-case perspective. Finally, the attack is assumed

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[11] The size of the defended footprint depends on the size of the attack, the interceptor flyout speed, the warhead signature (i.e., radar cross section and infrared radiated power), the character of the sensor support, i.e., the radar power-aperture product, the infrared optics, and the location of the sensors (e.g., ground-based radars within the continental United States, ground-based radars outside U.S. territory, or space-based acquisition and tracking sensors), and on the defense firing doctrine. In a barrage firing mode, multiple interceptors are fired at an incoming warhead near simultaneously. In a shoot-look-shoot mode, one or two interceptors initially are fired at each warhead, then a volley of interceptors is fired at any warhead that leaks through the first shot. Shoot-look-shoot firing doctrines are more efficient because subsequent interceptors are not launched if the warhead is destroyed in the first shot. However, they are more demanding technically because they require confident kill assessment after the first shot and they have smaller defended footprints because less flyout time is available for the second intercept attempt.

[12] See Russell Shaver, "Priorities for Ballistic Missile Defense," in *New Challenges for Defense Planning: Rethinking How Much Is Enough*, ed. Paul Davis, RAND, Santa Monica, CA, 1994, pp. 280–281.

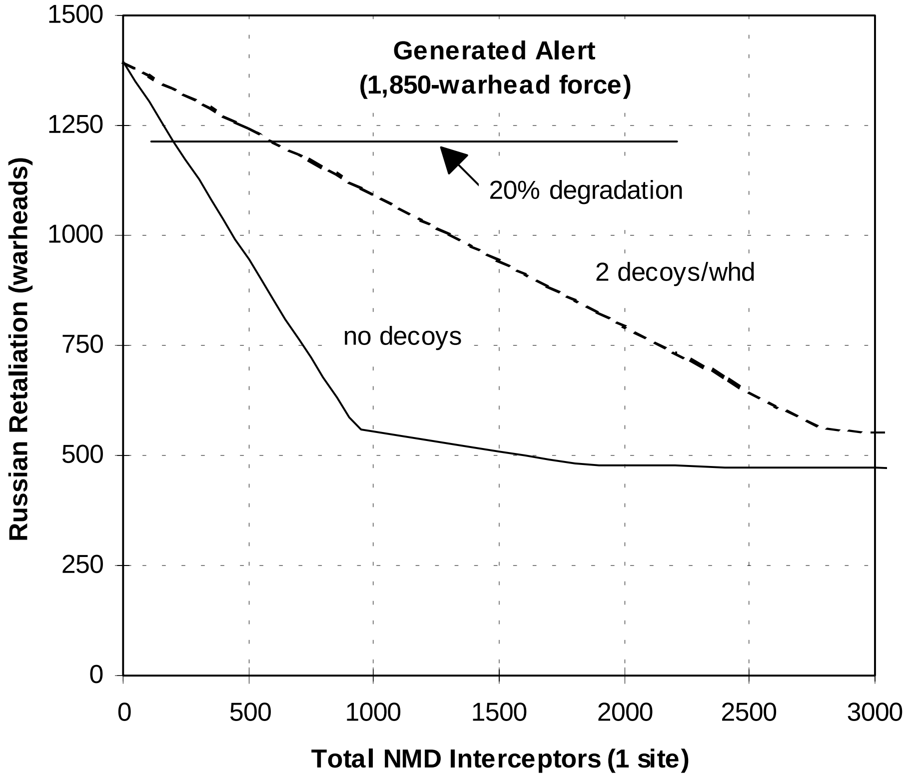

Fig. 2 - Russian START II/III Retaliatory Capability vs. U.S. NMD

to be uniform, as is the defense coverage.[13] Two different attack strategies are illustrated in Figure 2. The upper curve (dashed) assumes that two effective decoys are deployed with each Russian warhead.[14] The lower curve assumes no decoys are included in the attack. The Russian retaliatory capability on generated alert levels off at approximately 470 warheads

[13] More complex models would take into account the nonuniform value structure of the U.S. target base (e.g., the varying populations of different cities), preferential attack strategies, and preferential defense strategies. However, such modeling sophistication should not change the conclusions reached here.

[14] Two effective decoys are assumed for each warhead because Russian planners might believe that U.S. defenses could discriminate simple decoys (e.g., balloons, chaff, and booster fragments) from warheads, but not high-quality decoys designed to simulate warheads. The number of such high-quality decoys that could be deployed with each warhead is unknown. However, in the 1980s Great Britain apparently deployed two high-quality decoys, along with other penetration aids, for each Polaris SLBM warhead in the Chevaline program (see the appendix).

Table 1

Number of U.S. NMD Interceptors That Might Appear Threatening

	Offensive Attack Scenarios	
Scenarios	No decoys	2 decoys/warhead
Russia, Generated Alert		
2,430 warheads	310	930
1,850 warheads	205	620
1,320 warheads	105	215
Russia, Day-to-Day Alert	30–45	90–135
China, Generated Alert		
86–190 warheads	10–22	30–65

because this is the estimated size of the bomber retaliation. Finally, no warheads have been withheld from the Russian retaliatory strike for a secure reserve force.[15]

Therefore, using a 1,850-warhead Russian force as an example, approximately 205 NMD interceptors deployed at a single site might appear to Russian planners to degrade their ballistic missile retaliation by 20 percent, assuming all interceptors at this site can engage the incoming attack. This corresponds to a degradation of approximately 13 percent in the total Russian retaliatory capability if one includes bomber weapons. If multiple NMD sites area required for complete coverage of the United States, then Russia has the option of concentrating its retaliatory strike against targets located within one of the defended footprints. In this case, more NMD interceptors would be required to reduce the Russian ballistic missile retaliation by 20 percent.

A similar calculation can be made for different Russian force structures, or for Russian forces on day-to-day alert. The results are shown in Table 1. Obviously, the impact of defenses becomes more pronounced at lower force levels. The Russian force containing 2,430 warheads is close to the maximum Russia can deploy under START II. The 1,320-warhead force represents one that might result if Russian strategic force modernization is slowed by continued economic and political turmoil similar to that which has occurred over the past seven years. On day-to-day alert Russia would have a surviving retaliatory capability between 130 and 200 warheads, depending on which of the above force structures one assumes. The details of these force structures are given in the appendix.

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[15] The standard rationale for a secure reserve force is to ensure that a nuclear-armed state does not completely disarm itself after an all-out retaliatory strike against another state. This reserve nuclear capability presumably would be to deter further transgressions in the wake of a massive nuclear war. The number of weapons that are withheld for this purpose is debatable, although usually it is believed to be small (e.g., 10 percent of the force). The requirements for a secure reserve force have been ignored in these calculations because they don't substantially affect the conclusions reached here, unless the defense potential of a state can be reconstituted quickly after the initial attacks.

If the United States deploys a single-site NMD system, as is currently being discussed, then barrage-fire coverage of the continental United States is possible only for attacks coming from the north. In this case, the impact of the defense would be the same as for attacks directed at both sites for the two-site NMD system shown in Figure 2. That is, a single-site NMD system covering the entire country with 100 interceptors should not pose a realistic threat to the Russian strategic nuclear force until its total force approaches approximately 1,300 weapons (assuming no decoys), except on day-to-day alert (see Table 1).

The relative day-to-day alert vulnerability of Russian forces may create problems in a world with thin missile defenses because Russian leaders might feel pressure to generate their forces early in a crisis to improve their ability to deter the United States. This could have negative consequences for crisis management because signs that Russia is alerting its forces could lead to misperceptions that exacerbate, rather than stabilize, a crisis—despite the fact that force generation makes the nuclear balance more stable. Having said this, the likelihood of a nuclear crisis between the United States and Russia is remote in the current political environment. Moreover, increased transparency with respect to U.S. and Russian strategic force operations, as has occurred over the last six years due to military-to-military exchanges, reduces the likelihood of such misperceptions. Finally, if the political environment becomes more hostile, presumably over a period of months to years, Russia would have ample time to reconsider such low peacetime alert rates.[16]

Even if a thin U.S. national missile defense does not pose a realistic threat to Russia's strategic missile forces, it may provide the base for a more robust defense and, hence, constitute a breakout threat. Breakout is a concern only if the United States can achieve an exploitable strategic advantage. In fact, the United States would not attempt breakout unless it can achieve such an advantage. The level of defense that confers coercive leverage is uncertain, although it is likely to be a defense that can block at least 90 percent of the opponent's forces.[17] It would be difficult for the United States to achieve such an advantage

[16] To the extent Russian planners are concerned about day-to-day alert scenarios as they reduce the size of their strategic arsenal, they have several options for alleviating this relative vulnerability. First, Russia could maintain higher peacetime alert rates, i.e., deploy more submarines to sea, more mobile ICBMs out of garrison, and/or place bombers on alert (an option the former Soviet Union rarely practiced during the Cold War) if political relations with the United States deteriorate. The costs associated with higher alert rates may be prohibitive during peacetime, but would be justified if relations deteriorate. A second, less expensive option would be to place a fraction of Russian submarines in port, ICBMs in silos, and mobile ICBMs in garrison on a launch-under-attack posture. However, this is dangerous from the perspective of accidental, unauthorized, or inadvertent nuclear war—the latter being a particular concern today because of weaknesses in Russia's ballistic missile early-warning network. Consequently, this option should be strongly discouraged. Third, Russia could revise its day-to-day targeting doctrine to concentrate on targets located within fewer defended areas, thereby reducing the impact of the defense. Finally, Russia could deploy sophisticated decoys on its ballistic missiles. Of course, this would also reduce the U.S. defense effectiveness against Russian accidental and unauthorized attacks, though not against threats from other countries.

[17] History provides some clues as to the level of nuclear asymmetry required to provide coercive leverage. During the Cuban Missile Crisis the United States had a 6 to 1 advantage in deployed strategic nuclear weapons relative to the former Soviet Union. Moreover, U.S. preemptive counterforce options might have been fairly effective against Soviet forces at low alert levels. Under these circumstances, the United States probably had

because, although the radars and command and control elements—the long lead-time elements for a nationwide defense—already would be in place, any indication that more interceptors are being deployed would cause Russia to increase its alert rate. For a Russian forces with between 1,340–2,430 warheads, approximately 500–1,400 NMD interceptors would be required to block 90 percent of the Russian ballistic missile force on generated alert, assuming the attack does not include decoys and that it is spread evenly across the entire United States. Moreover, a substantial bomber force remains (734 warheads in the above forces). The time it would take the United States to reach these defense levels would give Russia time to load more warheads on ballistic missiles previously downloaded under START II (or START III) or on ballistic missiles with sufficient throw weight to carry more warheads (e.g., the SS-25 and SS-27 ICBMs, or the SS-NX-28 SLBM), deploy decoys or other penetration aids, and/or devise ways to suppress the defense.[18] Obviously, annual data exchanges on U.S. NMD programs and, more importantly, monitoring U.S. NMD interceptor production facilities would be useful confidence-building measures to help allay Russian breakout concerns.

National missile defenses would have greater impact on the retaliatory capabilities of China, France, and Great Britain. Table 1 also illustrates the size of a U.S. national missile defense that might pose a realistic threat to a Chinese strategic nuclear force containing between 86–190 long-range ballistic missile warheads. Note that China is not projected to have any long-range bombers capable of striking the United States.

If the United States deploys a thin national missile defense, Russia might deploy a comparable defense, although this seems unlikely due to Russia's current economic problems and the fact that Russian leaders have stated that U.S. defenses will stimulate offensive countermeasures and not comparable Russian defenses. Nevertheless, France, Great Britain, and China traditionally have been concerned that U.S. defenses might stimulate comparable Russian defenses and, hence, pose a threat to their strategic nuclear forces. Table 2 illustrates the size of a Russian national missile defense that might pose a realistic threat to the strategic nuclear forces of France, Great Britain, and China after absorbing a hypothetical Russian counterforce attack on generated alert—assuming four NMD sites are required to cover Russian territory with a barrage-firing doctrine and that its

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more than a 10 to 1 advantage in effective nuclear capability. While this leverage may have caused Moscow to take a more conciliatory stance in the crisis, President Kennedy apparently did not feel this advantage provided much coercive leverage because military options for destroying the Soviet missiles in Cuba were rejected out of fear the crisis could escalate, possibly to nuclear war and President Kennedy thought the United States did not have effective means for limiting damage to the U.S. homeland from a nuclear attack involving surviving missiles in Cuba or surviving Soviet strategic forces. See Scott Sagan, *Moving Targets: Nuclear Strategy and National Security*, Princeton University Press, 1989, pp. 30–32.

[18] The Russian upload capability under START II or START III depends on characteristics of Russia's future forces that are not readily apparent today. Nevertheless, Russia may be able to upload between 800 and 1,850 ballistic missile warheads under START II or START III (see the appendix).

Table 2

Number of Russian NMD Interceptors That Might Appear Threatening

	Offensive Attack Scenarios (Fraction of Russian Territory Attacked)			
Scenarios	100%	50%	25%	25% (2 decoys/warhead)
U.S., Generated Alert				
3,488 warheads	440	880	1,760	2,650
France	85	170	340	510
Great Britain	40	85	170	255
China, Generated Alert				
126–270 warheads	15–30	30–60	60–120	180–370

interceptors have SSPKs of 0.9 from French, British, or Chinese perspectives.[19] Table 2 also shows the size of the Russian defense that would pose a realistic threat to a 3,488-warhead U.S. START II force. The offensive missile forces assumed for France, Great Britain, and China are those that likely will be in existence in 10–15 years (see the appendix). Day-to-day alert retaliatory scenarios are not shown because they seem unlikely, although defenses would force these states to consider early force generation in a crisis or higher day-to-day alert rates. Note that the French and Chinese retaliatory capabilities against Russia include approximately 80 and 10–30 bomber weapons, respectively, some fraction of which would penetrate Russia's strategic air defense.

Table 2 illustrates four attack strategies for each country. The first represents an attack directed at targets spread evenly across Russia. The second corresponds to a retaliatory strike concentrated against targets located within half of the defended areas; the third an attack concentrated against targets located within a single defended footprint; and the last an attack directed at one defended footprint, but with two effective decoys deployed for each warhead.[20] The third attack strategy is most appropriate for these states because traditionally their targeting doctrines have been based on threatening only a few high-priority urban areas (e.g., Moscow), although this may be less true of the future Chinese nuclear doctrine.[21]

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[19] More sites are required to cover Russia because it is unlikely to develop a sensor architecture that can accurately track missiles early in their midcourse phase, i.e., it does not have any early-warning radars based outside its national territory and is unlikely to deploy space-based missile tracking sensors comparable to SBIRS-LEO.

[20] Little is known publicly about Chinese penetration aid programs. However, the DF-5 ICBM is reported to carry light exoatmospheric decoys and electronic countermeasures, but no heavy endoatmospheric decoys. See John Wilson Lewis and Hua Di, "China's Ballistic Missile Programs: Technologies, Strategies, Goals," op cit., p. 21.

[21] For French nuclear doctrine, both recent and past, see David Yost, "Nuclear Debates in France," *Survival*, Winter 1994–95, Vol. 36(4), International Institute for Strategic Studies, London, pp. 113–139, and "Nuclear Weapons Issues in France," *Strategic Views from the Second Tier*, John Hopkins and Weixing Hu, eds., Transaction

If NMD systems can achieve high technical performance, then a system containing 100 interceptors deployed at one or two sites around the United States may provide substantial protection against small accidental or unauthorized ballistic missile attacks containing up to 10–20 apparent warheads and provide insurance against the failure of deterrence if regional opponents acquire a few ICBMs in the future.[22] This level of national defense should not pose a serious threat to Russia's strategic nuclear force until reductions below approximately 1,300 weapons are reached, assuming the scenarios Russian planners worry about in the future are ones in which they have time to generate their forces. Similarly, such a defense, if deployed by Russia, should not pose a realistic threat to the strategic nuclear forces of France or Great Britain over the next decade or more, assuming their deterrent strategies allow them to concentrate their retaliatory strikes. China is the only nuclear power that might feel threatened by such a defense, although this depends on the exact size of China's future ICBM, SLBM, and IRBM force and whether it deploys effective penetration aids on these missiles.

How Much Theater Missile Defense Is Too Much?

The United States has pledged, in the Second Agreed Statement to the ABM Treaty signed on September 26, 1997, not to deploy TMD systems in number or location so as to pose a realistic threat to the Russian strategic nuclear force. Nevertheless, Russian (or Chinese) leaders may be concerned that TMD systems could pose a threat to their strategic nuclear force if they were surreptitiously deployed around the United States. If Russia deployed comparable TMD systems, the impact on French, British, and Chinese nuclear forces might also be of concern. The question is: What TMD levels might pose a realistic threat to the nuclear forces of the major nuclear powers?

There is relatively little debate that lower-tier TMD systems such as PAC-3 or the Navy Area Defense system do not pose a threat to the strategic nuclear forces of any of the five declared nuclear powers. More contentious are debates over upper-tier TMD systems such

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Publishers, New Brunswick, NJ, 1995, pp. 24–31. For British nuclear doctrine, see Nicholas K.J. Witney, "British Nuclear Policy after the Cold War," *Survival*, Winter 1994–95, Vol. 36(4), International Institute for Strategic Studies, London, pp. 96–112; and Michael Quinlan, "British Nuclear Weapons Policy: Past, Present, and Future," in *Strategic Views from the Second Tier*, op cit., pp. 125–140. Currently, a debate exists about China's nuclear strategy. The traditional view holds that China adheres to a "minimum deterrence" strategy based on the need to retaliate against a few high-priority urban areas. More recent work suggests that China may be shifting to a strategy of "limited deterrence" that stresses flexible targeting of a wider range of military and urban targets. See Litai Xue, "The Evolution of China's Nuclear Strategy," *Strategic Views from the Second Tier*, op cit., pp. 167–192; and Alastair Iain Johnston, "China's New 'Old Thinking': The Concept of Limited Deterrence," *International Security*, Vol. 20, No. 3 (Winter 1995/96), pp. 5–42.

[22] This assumes a warhead detection, tracking, and classification probability equal to 0.99 and interceptor single-shot probabilities of kill above 0.6. See Dean A. Wilkening, *How Much Ballistic Missile Defense Is Enough?*, CISAC Working Paper, Center for International Security and Cooperation, Stanford University, Stanford, CA, October 1998.

as the Theater High-Altitude Area Defense (THAAD) system and the Navy Theater-Wide (NTW) system slated for deployment on Aegis cruisers, and airborne boost-phase TMD systems (i.e., the Airborne Interceptor or Airborne Laser programs). These systems should provide more effective theater missile defense; however, they also have greater capability for intercepting strategic missiles.[23] This analysis concentrates on THAAD, as opposed to NTW, because THAAD is technically more mature (despite its five consecutive test failures) and, consequently, more information about its projected capabilities is available. Airborne boost-phase TMD systems will also be addressed.

Upper-Tier TMD Systems

To answer the question of whether THAAD poses a realistic threat to the Russian strategic nuclear force one must determine the number of THAAD sites required to cover U.S. national territory and the number of interceptors required at each site to pose a realistic threat.[24] If it is determined that such a defense does not pose a threat, one must still ask whether it provides a base for a more robust defense, thereby raising breakout concerns.

Based on the calculations of the Congressional Budget Office and others, a system like THAAD could have the ability to defend an area approximately 120 km in diameter (the footprint is roughly circular) against a single strategic reentry vehicle, assuming THAAD operates autonomously (i.e., the engagement is directed solely by the THAAD ground-based radar without external cueing).[25] The THAAD footprint against an attack involving multiple warheads, as would be the case in a large Russian attack, would be smaller because the radar must share its time among multiple incoming targets. At some point the attack becomes so large that the track-handling capability of the radar is saturated. Nevertheless, using a 120 km footprint diameter as a worst case from the Russian perspective one can see from Figure 3 that the THAAD system operating autonomously does not pose a realistic threat to Russia's strategic nuclear forces, or to those of any nuclear power with long-range missiles, because

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[23] For an argument that upper-tier TMD systems will have strategic BMD capability see Lisbeth Gronlund, George Lewis, Theodore Postol, and David Wright, "Highly Capable Theater Missile Defenses and the ABM Treaty," *Arms Control Today*, April 1994, pp. 3–8.

[24] The United States would not necessarily have to cover its entire national territory to undermine the Russian deterrent. However, it is difficult to know what fraction of U.S. territory, if defended, would appear threatening because this depends on the geographic distribution of targets Russian leaders believe they must hold at risk for deterrence. Therefore, this analysis assumes that the entire national territory would have to be defended. The fraction of Russian territory that would have to be defended to undermine the U.S. deterrent is smaller because of the large expanses of thinly populated Russian territory.

[25] This is the range out to which a THAAD intercept is kinematically possible against a strategic warhead traveling at 7 km/sec. These calculations do not purport to determine the probability of kill within this footprint. Nevertheless, Russian analysts would likely plan for the worst and assume that, where an intercept is possible, the kill probability could be high—even for interceptors tested against targets traveling no faster than 5 km/sec. See *The Future of Theater Missile Defense*, the Congressional Budget Office, Washington, D.C., June 1994, p. 55; and Lisbeth Gronlund et al., "Highly Capable Theater Missile Defenses and the ABM Treaty," op cit., pp. 3–8.

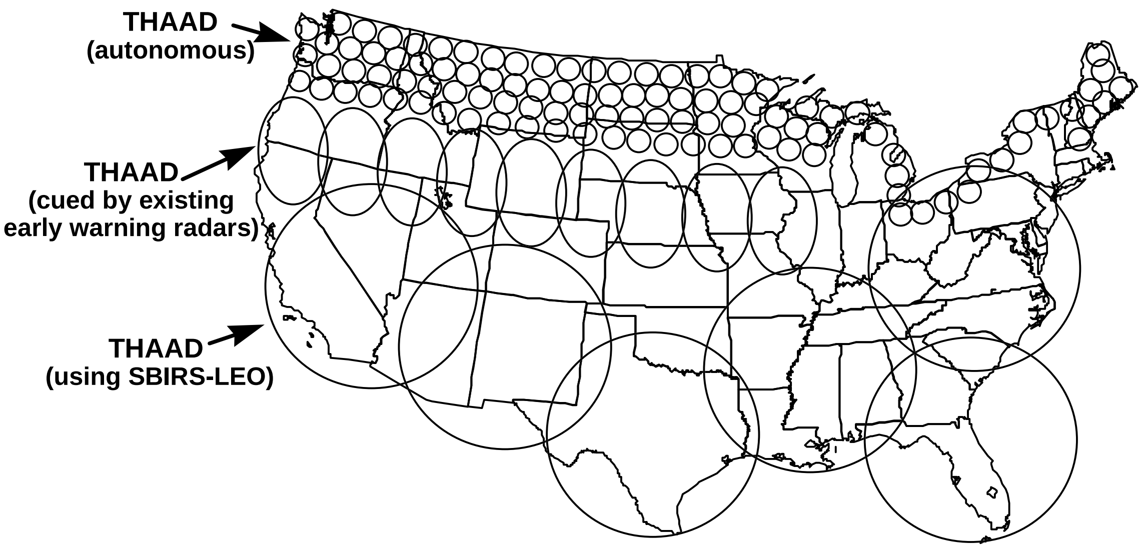

Fig. 3 - THAAD Coverage of the United States

the current program, consisting of eight THAAD batteries, cannot cover much of the continental United States.[26] Nearly 1,000 autonomously operated THAAD batteries or sites would be required to cover the entire United States.

If the THAAD ground-based radar is cued using track information from existing early-warning radars, then the hypothetical THAAD footprint for a single engagement expands to an ellipse approximately 400 km wide by 625 km long in the direction of the missile's flight (see Figure 3).[27] Still about 50 cued THAAD footprints are required to cover the continental United States for northerly attacks. If attacks from all azimuths (e.g., from SLBMs off U.S. coasts) must be taken into account, the THAAD enforceable footprint becomes roughly circular and shrinks to around 350–400 km in diameter. In this case, approximately 80 sites would be required to cover the continental United States. Again, the current THAAD program cannot cover much of the continental United States.

The NTW interceptor will have a maximum flyout speed of approximately 4.5 km/sec, i.e., two-thirds greater than that for THAAD. Hence, the NTW system will have footprints nearly three times the area of the THAAD footprints shown in Figure 3, assuming equal interceptor flyout times. Consequently, the NTW system cannot defend the interior of the United States from coastal waters if it operates autonomously or is cued by existing early-warning radars, although it may be able to defend important coastal cities (which include a large fraction of the U.S. population). Therefore, NTW should not pose much of a threat to Russia's strategic forces, although clearly it will be of greater concern than THAAD.

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[26] The current plan is to produce 1,233 THAAD interceptors and 14 ground-based radars to be deployed in eight THAAD batteries. See Michael Dornheim, "Missile Defense Soon, But Will It Work?," *Aviation Week and Space Technology*, February 24, 1997, p. 39.

[27] See *The Future of Theater Missile Defense*, the Congressional Budget Office, op cit., p. 60.

The only circumstance where the THAAD or NTW systems could appear to pose a realistic threat to any state, i.e., have substantial coverage of the United States, occurs when TMD interceptors are guided in flight using a sensor that can obtain accurate track data during the early midcourse portion of a ballistic missile's trajectory. These sensors might be upgraded early-warning radars located outside the United States or the SBIRS-LEO satellite using long-wave infrared sensors to track objects against the cold background of outer space.[28] In this case, the hypothetical THAAD footprint against 7 km/sec missiles increases to an area approximately 1,100 km in diameter, implying that 10–12 THAAD sites would cover the continental United States (see Figure 3).[29] Approximately three to four NTW footprints would be required under these circumstances. However, neither THAAD nor NTW is being designed to accept track data in flight except from their ground-based or sea-based radars. Nevertheless, if SBIRS-LEO is deployed, Russian planners fearing the worst might believe that 10–12 THAAD sites, or 3–4 NTW sites, could provide total coverage of the continental United States.

Even so, there is the question of whether the defense has sufficient depth to pose a realistic threat to Russian strategic missiles. Figure 4 illustrates the Russian retaliatory capability for a 1,850-warhead force, after absorbing a hypothetical U.S. counterforce attack on generated alert, as a function of the total number of THAAD interceptors deployed at 10 sites around the United States, i.e., assuming Russian planners believe SBIRS-LEO can be used to guide THAAD intercepts directly. The family of curves corresponds to attacks concentrated against targets located in different subsets of the defended areas to saturate the defense. The curves level off at 470 warheads because this represents the number of Russian bomber weapons that are assumed to penetrate U.S. air defenses. A barrage firing doctrine is assumed for the defense with each interceptor having an SSPK of 0.8 against strategic warheads, from the Russian perspective.[30] The attack also is assumed to be uniform, as is the defense coverage, and no warheads are withheld for a Russian secure reserve force.

Therefore, approximately 230, 460, 1,160, or 2,300 THAAD interceptors deployed at 10 sites could lead Russian planners to believe that 20 percent of their ballistic missile retaliatory capability could be blocked if the ballistic missile retaliation for a 1,850-warhead force is aimed at targets located within 10, 5, 2, or 1 defended area(s), respectively. Obviously, concentrating the attack increases the required number of TMD interceptors. If Russia deploys effective decoys, then proportionately more interceptors would be required to pose

[28] This assumes two or more satellites are used for triangulation or that SBIRS-LEO has an onboard lidar for accurate range measurements.

[29] Again, this coverage is based on single-missile engagement footprints. The assumption that the single-engagement THAAD footprint accurately reflects the defended area is weak in this case because each of these defended areas potentially must defend against hundreds, if not thousands, of incoming warheads and decoys simultaneously, a large fraction of which could arrive close in time.

[30] The SSPK for TMD interceptors against Russian strategic warheads is assumed to be smaller than that for NMD interceptors because TMD interceptors cannot be tested against targets traveling faster than 5 km/sec and hence would have lower SSPKs against such targets.

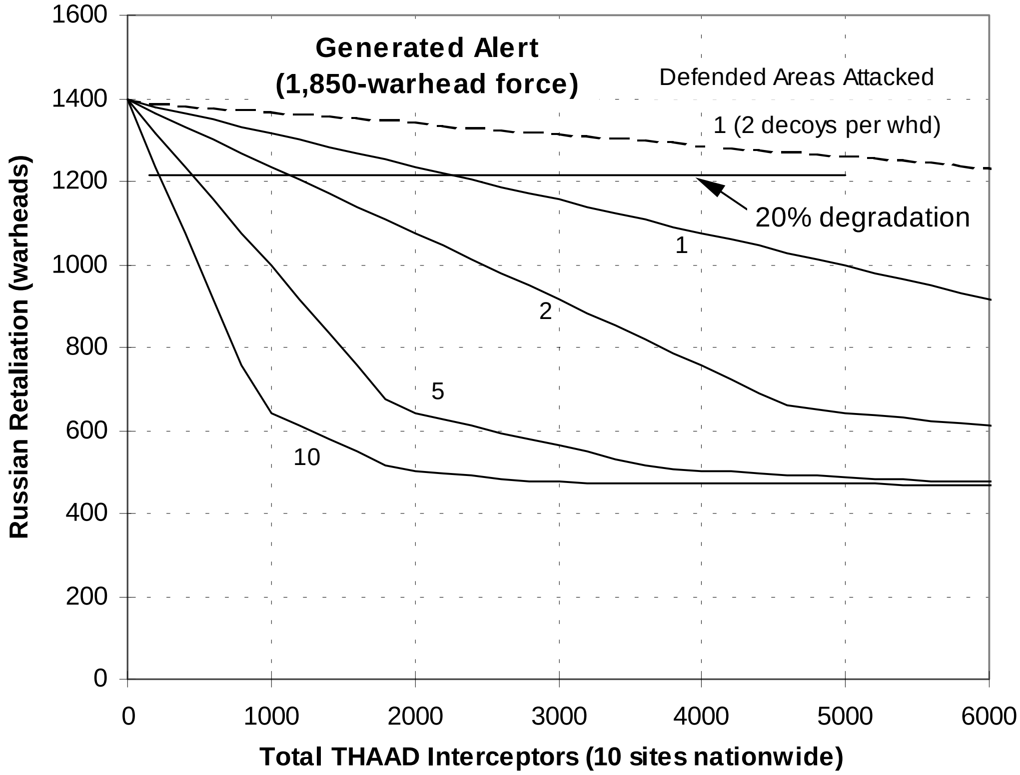

Fig. 4 - Russian Retaliation vs. THAAD w/SBIRS-LEO (START II Forces)

a realistic threat. Though the defense would have greater impact if Russian forces are on day-to-day alert, this scenario is ruled out (unlike in the discussion of national missile defense) because Russia would not keep its forces on low states of alert if the United States deployed TMD systems around the United States contrary to assurances not to deploy them in this manner. Table 3 shows the number of THAAD interceptors, deployed at 10 sites across the United States, that might appear to pose a realistic threat for three different Russian strategic force levels on generated alert. Table 3 also shows the impact of U.S. TMD systems on the Chinese strategic retaliatory capability.

Consequently, if Russian planners fear that the current THAAD program could provide complete coverage of the United States (even though only eight batteries are planned) and that approximately 1,200 interceptors could surreptitiously be deployed around the continental United States, then they would have to alter their targeting doctrine to concentrate on targets located in no more than three defended areas to guarantee that less than 20 percent of a 2,430-warhead Russian strategic nuclear force could be intercepted. Similarly, Russian planners would have to concentrate their retaliatory strike against targets located in two, or one, defended area(s) if the current THAAD program is not to appear

Table 3

Number of THAAD Interceptors That Might Appear Threatening

Force Structures	THAAD Interceptors That Might Pose a Realistic Threat (Fraction of U.S. Area Targeted) 100%	50%	30%	20%	10%
Russian Force, Generated Alert					
2,430 warheads	350	700	1,150	1,740	3,500
1,850 warheads	230	460	760	1,160	2,300
1,320 warheads	120	240	400	600	1,200
Chinese Force, Generated Alert					
86–190 warheads	11–25	23–50	40–80	60–120	115–250

threatening to an 1,850-warhead or 1,320-warhead Russian force, respectively. If effective decoys are deployed, the numbers in Table 3 would be proportionately higher.

Therefore, if THAAD interceptors can be guided in flight by sensors such as SBIRS-LEO, then the current THAAD program is likely to appear threatening to Russian leaders at START II or START III force levels, unless they believe that threatening targets located in a subset of U.S. territory is sufficient for deterrence, or unless two or more effective decoys can be deployed with each missile warhead. Note that the Russian bomber force still represents a formidable deterrent on generated alert, regardless of the attrition Russian ICBMs and SLBMs might suffer. Consequently, maintaining a sizable bomber force also reduces the concerns Russian leaders might have with U.S. ballistic missile defenses.

If NTW engagements are conducted using accurate track data from sensors such as SBIRS-LEO, then the number of NTW interceptors that could intercept 20 percent of the Russian strategic missile force is the same as the number of THAAD interceptors shown in Table 3, assuming NTW interceptors also have an SSPK of 0.8 against strategic warheads. Recall that three to four NTW sites would be sufficient to cover the continental United States under these circumstances, so concentrating the attack against one defended area corresponds to an attack against 30 percent of the U.S. territory in Table 3. According to the current plan, 650 NTW interceptors will be deployed.[31] Hence, this program might also appear threatening to Russian planners unless they modify their targeting doctrine to hold at risk targets located in only one NTW defended footprint (i.e., either the east or west coast). If holding targets at risk within a single NTW footprint is sufficient for deterrence, then Russia can reduce its total strategic force to approximately 1,700 warheads before 650 NTW interceptors poses a realistic threat. Note that NTW may appear more threatening than THAAD because SBIRS-LEO may be required in any case for cueing due to the relatively low power of the Aegis radar and because indications that NTW is being deployed as a

[31] See Michael Dornheim, "Missile Defense Soon, But Will It Work?," op cit., p. 39.

national missile defense are less noticeable if NTW footprints can cover the United States from ports along the U.S. coastline.

Finally, if THAAD and NTW are both deployed—a questionable assumption in the current fiscal environment—and a joint command and control system can efficiently allocate these interceptors, then Russian planners would have greater reason for concern. If 1,200 THAAD interceptors are deployed at 10 sites and 650 NTW interceptors are deployed at three sites, then Russia would have to maintain a strategic force larger than approximately 2,400 warheads, i.e., the high end of the START III Treaty limit, to suffer less than 20 percent attrition if its retaliatory strike is concentrated against targets located in a single THAAD footprint located within one NTW footprint. In this case, deploying effective decoys would be necessary to minimize the impact on Russia's retaliatory capability.

Even if U.S. TMD systems do not pose a realistic threat to Russia's strategic nuclear force, they could provide a base for a national defense, thereby raising concerns about strategic BMD breakout. Again, breakout is a concern only if the defender can achieve an exploitable strategic advantage—assumed in this analysis to be a defense that can block at least 90 percent of the opponent's strategic missile force as discussed above for NMD breakout.

Figure 5 illustrates the two dimensions of TMD breakout—the number of sites required for national coverage and the depth of the defense. The thresholds in this figure are chosen assuming an 1,850-warhead Russian force on generated alert and that the retaliation is aimed at targets spread across all defended areas. The current THAAD program is represented by the point in the figure. The distance from this point to the effective national missile defense domain represents the breakout required for an effective NMD capability. Approximately 1,500 THAAD interceptors deployed around the United States are required to defeat 90 percent of the Russian ballistic missile retaliation for the 1,850-warhead Russian force described in the appendix.[32] Hence, the current THAAD program is perilously close to what Russian planners, using worst-case assumptions, might consider to be an effective U.S. TMD breakout capability against Russian START III forces, assuming they also believe that THAAD interceptors can be guided in flight using accurate track data from the early midcourse phase of Russian ballistic missile trajectories.

The breakout time is the time it would take to build additional THAAD missiles, launchers, and radars or other sensors. If the breakout time for the defense is short relative to the time the offense needs to respond, then breakout becomes a serious concern. Traditional ABM breakout concerns focused on ABM radar production since this was the key long-lead-time item. This is less true with respect to theater missile defense, implying that TMD missile, launcher, and radar production facilities should all be monitored to allay

[32] Note that the number of interceptors required for effective TMD breakout does not depend on whether THAAD is cued by existing early-warning radars or whether THAAD engagements are conducted with accurate SBIRS-LEO track data because the retaliatory strike is directed at all of the defended areas in either case. Only the number of sites required for adequate coverage changes.

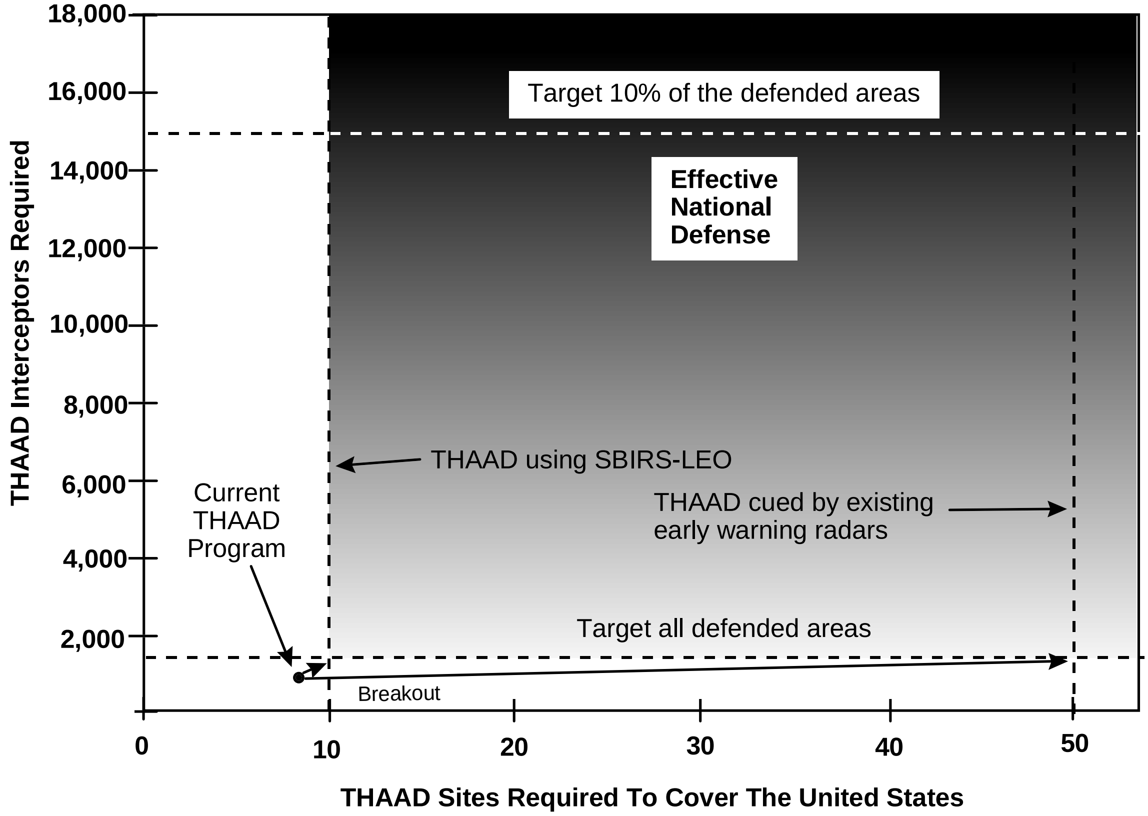

Fig. 5 - TMD Breakout Potential (1,850-warhead Russian Force)

fears of TMD breakout, with the latter being of less concern if SBIRS-LEO is used to conduct the engagements.

Russia has three options for responding quickly to U.S. TMD breakout. First, it can change its targeting doctrine to threaten targets in fewer defended areas, especially as an interim measure. If Russia changes its targeting doctrine to threaten targets in only one-tenth of the defended areas, then the United States would have to deploy approximately 15,000 THAAD interceptors for an effective national missile defense against a 1,850-warhead Russian force. Second, Russia can increase the size of its ballistic missile arsenal by 800–1,850 warheads, depending on the exact Russian force structure under START II (or START III), by adding warheads to missiles previously downloaded under START II or by deploying more highly MIRVed versions of new ICBMs and SLBMs (see the appendix)—although it would take some time to build and test the new post-boost vehicles for the latter option. Increasing the arsenal by this amount would require roughly doubling the number of THAAD interceptors shown in Figure 5 to provide the same level of defense. In this regard, retaining extra strategic warheads in the stockpile as a hedge against TMD breakout is a stabilizing measure. If THAAD production continues beyond the Russian upload capacity, and retargeting is deemed unacceptable, then breakout could be a serious concern because

THAAD missile and launcher production probably can outpace the rate at which Russia can deploy new strategic delivery vehicles.

To allay breakout concerns the United States and Russia agreed that TMD systems "will not be deployed by the Parties for use against each other," and that "the scale of deployment—in number and geographic scope" will be consistent with the threats confronting that Party.[33] Confidence-building measures were also included that provide for annual data exchanges on each side's TMD programs, identification of TMD test ranges, and 10-day advance notice for TMD tests. In addition, each side should be allowed to monitor TMD garrisons and TMD missile, launcher, and radar production facilities as additional confidence-building measures. This would help reduce breakout concerns, especially if several thousand U.S. upper-tier TMD interceptors are deployed along with SBIRS-LEO.

One of the most challenging tasks for U.S. TMD policy will be to convince Russian leaders that upgraded early-warning radars and SBIRS-LEO, if deployed with the capability to accurately track warheads, will be adjunct sensors and will not be capable of directly guiding TMD interceptors in flight.[34] Otherwise, Russian leaders may believe that upper-tier TMD systems have a modest NMD capability. One way to retain some of the advantages associated with the long-wave infrared sensors aboard SBIRS-LEO (e.g., for decoy discrimination) that minimizes conflicts with the ABM Treaty would be to place them on high-altitude aircraft (similar to the Airborne Optical Adjunct from the SDI program).[35]

If Russia deploys advanced TMD systems (an unlikely scenario in the next 5–10 years), they probably will have smaller footprints than U.S. systems because Russia will have difficulty deploying satellites comparable to SBIRS-LEO and Russia does not have any early-warning radars located outside the territory of the former Soviet Union. Using the cued THAAD footprint to be representative of a system Russia might be able to deploy in the future, approximately 50–100 THAAD-like footprints would be required to cover the populated regions of Russia. Table 4 illustrates the potential impact of a hypothetical Russian

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33 See U.S. Arms Control and Disarmament Agency (ACDA), *Second Agreed Statement Relating to the Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems of May 26, 1972* (Washington, DC: ACDA, September 26, 1997).

34 It is hard to escape the conclusion that SBIRS-LEO, if it can provide accurate track data, can substitute for ABM radars and, hence, is a straightforward violation of Agreed Statement D of the ABM Treaty. Using SBIRS-LEO as an adjunct sensor, e.g., for cueing, is permitted by the ABM Treaty.

35 Airborne systems have less ability to track strategic ballistic missiles in their midcourse phase unless they are stationed far forward, e.g., over northern Canada and the Atlantic and Pacific oceans in the case of Russian missile attacks. While such deployments are not impossible, they are operationally difficult because of the large number of aircraft required to cover all possible launch azimuths for Russian ICBMs and SLBMs. Therefore, airborne long-wave infrared sensors deployed near THAAD or Navy Theater-Wide defenses could be useful adjuncts to TMD radars but would have less ability to extend THAAD or NTW coverage of the continental United States.

Table 4

Number of Russian Upper-Tier Interceptors That Might Appear Threatening

Force Structures	100%	50%	30%	20%	10%
	Upper-Tier Interceptors (Fraction of Russian Territory Targeted)				
U.S., 3,488 warheads	500	1,000	1,640	2,500	5,000
France	95	190	315	480	960
Great Britain	50	100	160	240	480
China, 126–270 warheads	17–35	35–70	55–115	85–175	170–350

TMD system on the strategic retaliatory capability of France, Great Britain, and China.[36] Again, since these states have targeting doctrines that emphasize holding at risk only a few high-priority urban areas, concentrating their retaliatory strikes against targets located within 10 percent of Russian territory (i.e., 5–10 defended sites) might be acceptable. If the retaliatory strike is directed against targets located within a single defended footprint, then 5–10 times more TMD interceptors than shown in Table 4 would be required. Proportionally more upper-tier TMD interceptors would be required if France, Great Britain, or China deploys effective decoys.

Again, debates about what French, British, and Chinese leaders believe is sufficient for deterrence are central to an understanding of the impact of Russian TMD systems. Nuclear targeting doctrines certainly would be reassessed in the presence of Russian defenses. In any case, Russian TMD deployments should not appear threatening to three of the four nuclear powers until 500–1,000 Russian THAAD-like interceptors are deployed, China being the sole exception. Although the arsenals of the medium nuclear powers are smaller, the number of TMD interceptors required to pose a realistic threat remains fairly high because their targeting doctrines allow highly concentrated attacks.

In summary, the current THAAD and NTW programs may appear threatening to Russian planners at START II or START III levels if they believe upper-tier interceptors can be guided in flight by accurate track information from space-based sensors or upgraded early-warning radars located outside the United States. However, this threat is reduced substantially if Russian leaders believe that deterring the United States only requires holding at risk targets spread across 10–30 percent of the United States. Obviously, convincing Russian leaders that these TMD systems cannot conduct intercepts using accurate midcourse track data will be important for making current U.S. TMD programs, if deployed, appear to be in compliance with the ABM Treaty, as modified by the ABM Treaty Demarcation Agreements signed on September 26, 1997.

[36] This exaggerates the Chinese retaliatory capability somewhat because the DF-21 IRBMs cannot reach western Russia (i.e., Moscow).

Airborne Boost-Phase TMD

If the United States deploys airborne boost-phase TMD systems, i.e., the Airborne Interceptor (ABI) or Airborne Laser (ABL) systems, the question naturally arises as to whether these systems might not pose a realistic threat to Russian strategic nuclear forces.[37] After all, if these systems are effective against theater-range ballistic missiles, they should also be effective against intercontinental-range ballistic missiles since the boost times of the latter are longer (typically between 200–300 seconds for ICBMs and SLBMs, depending on their range and fuel type). These longer boost times extend the kinematically feasible ABI intercept range and the time the ABL can illuminate a missile booster. Contrary to this initial impression, airborne boost-phase TMD systems do not pose a realistic threat to Russian strategic ballistic missiles, as this section will argue.

Using 200 seconds for the nominal ABI flyout time against solid-fuel ICBMs and SLBMs, intercept ranges for 3 km/sec, 4 km/sec, and 6 km/sec ABIs, the feasible range for ABI flyout speeds, are approximately 450 km, 600 km, and 950 km, respectively, although ABIs may not be very effective beyond their design ranges of several hundred kilometers because they will have difficulty homing on targets at extreme ranges.[38] Nevertheless, from a Russian worst-case perspective, these kinematically possible ABI intercept ranges may be of concern. The maximum range of the ABL against strategic missiles probably will be around 300–400 km.[39] Hence, of the two options, the ABI should appear more threatening to Russian strategic planners.

However, practical considerations limit the extent to which ABIs can be used against strategic missiles. First, airborne sensors for detection and tracking will have a 500–600 km line of sight to missiles at 10 km altitude, assuming the sensor platform flies at 40,000 ft. Therefore, sensor constraints will limit the ABI intercept range to less than 600 km, regardless of ABI flyout speed, unless the sensor platform flies at higher altitudes or closer to the boosters than the ABI launch platforms (of which the latter is unlikely). Space-based radars or short-wave infrared sensors that can be linked to ABI launch platforms would eliminate this constraint; however, they are difficult to build with sufficient jam resistance.

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[37] The ABI is a small chemical rocket carried by fighter aircraft or unmanned aerial vehicles designed to home on the hot exhaust plume from a ballistic missile under powered flight. It destroys the ballistic missile by direct impact. The ABL is a high-power laser carried aboard a Boeing 747 aircraft designed to illuminate the side of a ballistic missile booster with a very intense laser beam. It destroys the ballistic missile by causing the booster to collapse under the axial load during boost phase or by burning a hole in the booster's side, causing premature thrust termination.

[38] See Dean A. Wilkening, *Airborne Boost-Phase Theater Missile Defense*, CISAC Working Paper, Center for International Security and Cooperation, Stanford University, to be published.

[39] Geoffrey Forden calculates the lethal range of the ABL against an SS-18 to be between 300 km and 400 km. The lethal range against other Russian ICBMs and SLBMs may be on the same order of magnitude. See Geoffrey Forden, *The Airborne Laser: Shooting Down What's Going Up*, CISAC Working Paper, Center for International Security and Arms Control, Stanford University, 1997, pp. 14–15.

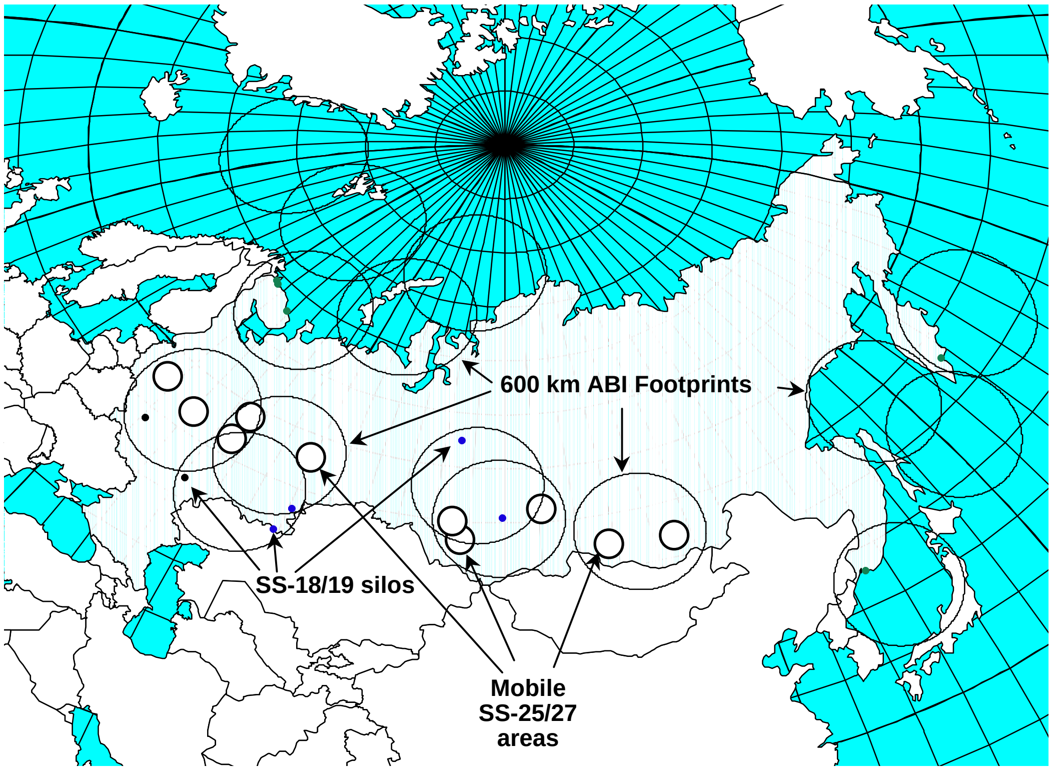

Fig. 6 - ABI Coverage of Russian ICBM and SLBM Launch Locations

With a nominal ABI lethal range of 600 km against strategic ballistic missiles, it takes eight to nine such footprints to cover the Russian missile-carrying submarine (SSBN) bastions near Russian territory, although this number shrinks to four to five footprints if the future Russian SLBM force is located entirely with the Northern Fleet, as seems likely (see Figure 6). If Russian SSBNs deploy into the open ocean, an option that certainly is possible despite the Russian preference for basing them in bastions, then more than 60–80 ABI footprints would be required to cover all possible SLBM launch locations (or 20–30 footprints if the SSBNs are deployed only in the North Atlantic).

If Russia deploys single-warhead ICBMs in former SS-18 and SS-19 silos under START II and deploys up to 350 mobile SS-25s/Topol Ms at 10 garrisons, then up to six additional 600 km-range ABI footprints would be required over Russian territory to cover all possible ICBM launch locations, as shown in Figure 6.[40] The mobile ICBM deployment areas are

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[40] The actual number may be higher because the Topol M is reported to have a more powerful booster and a shorter burn time compared with the Topol (SS-25) ICBM. See Nikolai Sokov, *Modernization of Strategic Nuclear Weapons in Russia: The Emerging New Posture*, Working Paper No. 6, Program on New Approaches to Russian Security, Davis Center for Russian Studies, Harvard University, Cambridge, MA, May 1998, p. 34.

shown as 150 km radius circles in Figure 6 to represent the area into which mobile ICBMs could deploy within 10 hours (one night's travel) after leaving their garrison. Larger deployment areas may be possible but problems with logistics support and effective command and control eventually limits the size of these deployment areas.

Therefore, the United States would have to maintain aircraft aloft continuously in at least 10–11 orbits to cover Russian ICBM and SLBM launch locations in the future, and between 25–35 orbits if Russia sends its SSBNs into the North Atlantic Ocean. The number of footprints required for adequate theater missile defense is approximately five.[41] Therefore, defending against Russian strategic missiles requires more, and perhaps many more, ABI/ABL launch platforms than for theater missile defense. Moreover, these footprints would require a large number of sensor platforms and tankers to keep the ABI or ABL platforms airborne 24 hours a day. In short, the magnitude of the airborne operation required to adequately cover all possible Russian ICBM and SLBM launch locations is daunting, making the feasibility of such an operation suspect on force structure grounds alone.

More importantly, ABI and ABL platforms, airborne sensor platforms, and tankers are all vulnerable to Russian air defenses. It is difficult to imagine how the United States could conduct ABI or ABL operations over or near Russian territory without having a large number of aircraft shot down in a crisis or war.[42] Moreover, the airfields from which ABI or ABL operations originate would be vulnerable to Russian attack because these airfields are few in number and relatively easy to identify. Finally, Russian salvo launches would also reduce the effectiveness of any residual airborne boost-phase TMD system. Recognizing this, the United States would never deploy its airborne boost-phase TMD assets in this manner.

Therefore, U.S. airborne boost-phase TMD systems will not pose a realistic threat to Russian strategic nuclear forces largely for operational reasons and not because these systems cannot shoot down strategic missiles if they are within range. Moreover, U.S. airborne boost-phase TMD systems pose relatively little threat to Chinese strategic missile forces because their modern JL-2 SLBMs will be deployed in too large an area and ABI/ABL platforms would have to penetrate Chinese airspace to cover all possible Chinese ICBM launch locations. Similarly, if Russia ever develops airborne boost-phase TMD systems in the future, they would not pose a threat to French, British, or Chinese strategic missile forces. However, airborne boost-phase TMD systems may be effective against small regional adversaries such as North Korea and Iraq because their missiles are located in

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[41] See Dean A. Wilkening, "How Much Ballistic Missile Defense Is Enough?," CISAC Working Paper, Center for International Security and Cooperation, Stanford University, September 1998.

[42] This is true even if one assumes the United States launches a nuclear first strike against Russian air defenses, because many of the modern land-based surface-to-air missiles (e.g., the SA-10 and SA-12) and naval surface-to-air missiles are mobile. In addition, air defense fighters can escape on warning, depending on their alert status, to recover at remote airstrips that have not been destroyed.

smaller geographic areas and these countries have relatively weak air defenses. Therefore, airborne boost-phase TMD systems potentially are the most effective type of theater missile defense, yet they do not pose a threat to the strategic missile forces of the five major nuclear powers.

Consequently, airborne boost-phase TMD systems might be an interesting area for collaboration between the major nuclear powers, if one is willing to believe that the end of the Cold War has created possibilities for defense cooperation that never existed before. In particular, Russian technical strengths in high-speed chemical rockets and high-power lasers could be combined with U.S. strengths in sensors and precision optical systems to produce an interesting collaboration on ABI or ABL systems.

Concluding Observations

With respect to national missile defense, the United States could deploy up to 100–300 NMD interceptors, depending on the size of the future Russian strategic nuclear force, without posing a realistic threat to these forces, i.e., without threatening to intercept more than 20 percent of the ballistic missile retaliation in a 1,300–2,400 warhead Russian force on generated alert. Reductions below the level of 1,300 warheads in the presence of a 100-interceptor defense would require Russia to deploy effective decoys or change its targeting doctrine to concentrate on targets located in fewer defended areas, assuming the U.S. NMD system consists of multiple NMD sites. The impact of a 100-interceptor national missile defense on the Russian day-to-day alert retaliatory strike would be larger, but day-to-day alert scenarios are less plausible. Again, deploying decoys or concentrating the attack, if possible, would reduce the impact of a thin national defense on the Russian day-to-day alert retaliation.

NMD breakout, in principle, may also be a concern because much of the infrastructure for a more robust national missile defense would already be in place. However, such concerns are not too serious at START II or START III force levels because of the large number of additional interceptors that would be required to achieve an exploitable strategic advantage. Retaining the ability to reload warheads on ballistic missiles downloaded under previous arms control agreements, or to increase the MIRV loading on new ICBMs and SLBMs, helps alleviate breakout concerns.

Thin national missile defenses would have a greater impact on the retaliatory capabilities of France, Great Britain, and China. U.S. or Russian NMD systems with 100 interceptors would pose a realistic threat to China unless China concentrates its attack and deploys one or more effective decoys for each ballistic missile warhead. The impact of a Russian defense is somewhat less because China can threaten Russian territory with IRBMs in addition to ICBMs and SLBMs, and because any future Russian NMD system likely will require more sites for adequate coverage, thus allowing greater attack concentrations. A thin Russian national missile defense would have to contain no more than 340 interceptors to intercept less than 20 percent of the French SLBM retaliation, or 170 interceptors to intercept less than 20 percent of the British SLBM retaliation, on generated alert—assuming their retaliatory strikes are aimed at facilities located within one of the four defended areas assumed for Russia. Deploying sophisticated decoys similar to those the British reportedly deployed under the Chevaline program in the 1980s would further reduce the threat posed by a thin Russian national missile defense.

Therefore, a modified ABM Treaty that allows the United States and Russia to deploy 100 interceptors at multiple sites around their national territory should not pose a realistic threat to the retaliatory capabilities of four of the five declared nuclear powers on generated alert, China being the sole exception. Since 100 NMD interceptors should be adequate for defending the United States against small accidental or unauthorized attacks, or against intentional threats from regional powers that may acquire a few ICBMs in the next decade or more, it should be possible to deploy a thin U.S. national missile defense without posing a realistic threat to four of the five declared nuclear powers. Nor would such a defense interfere with further U.S.-Russian strategic arms control, at least down to a level of approximately 1,300 nuclear weapons. Finally, one should note that bombers and sea-launched cruise missiles will become increasingly important in a world with ballistic missile defenses.

U.S. theater missile defenses capable of providing protection against future regional threats will require layered defense architectures with between 1,000–2,000 high-performance upper-tier TMD interceptors and a somewhat smaller number of lower-tier interceptors such as the Patriot Advanced Capability (PAC-3) system.[43] The only way for the United States to deploy such a defense without having it appear threatening to Russia—in the unlikely scenario that U.S. TMD interceptors are deployed around the continental United States—is to convince Russian leaders that these TMD systems cannot conduct intercepts using accurate midcourse track data from space-based sensors such as SBIRS-LEO or upgraded early-warning radars located outside the United States. If this cannot be done, Russian planers likely will conclude that U.S. upper-tier TMD systems will pose a threat to their strategic nuclear force, thereby violating the ABM Treaty Demarcation Agreement. The quickest way for Russia to redress this vulnerability is to change its targeting doctrine to hold at risk targets located in a portion of the United States. Deploying effective decoys likely will be the preferred long-term solution. For example, for a Russian strategic force with 1,320–2,430 warheads, the current THAAD program (1,233 interceptors) would not pose a realistic threat if the Russian retaliatory strike is concentrated against targets located within 10–30 percent of the United States. Similarly, the current NTW program (650 interceptors) should not pose a realistic threat provided Russia maintains a strategic force with more than approximately 1,700 warheads and the Russian retaliatory strike is aimed at targets located within one NTW defended footprint. Obviously, U.S. assurances not to deploy these systems around the continental United States help reduce the concern with this scenario,

[43] See Dean A. Wilkening, "How Much Ballistic Missile Defense Is Enough?," CISAC Working Paper, Center for International Security and Cooperation, Stanford University, October 1998.

although additional confidence-building measures should be considered, e.g., reciprocal monitoring of each other's TMD garrisons and TMD production sites.

The hypothetical impact of Russian upper-tier TMD systems on the retaliatory capabilities of France and Great Britain may also be manageable, provided no more than approximately 500–1,000 Russian THAAD-like interceptors are deployed, because the targeting doctrines of these states only call for threatening targets located within a few defended areas, although effective decoys become more important in these cases. Again, the impact on China would be greater.

The main limitation of upper and lower-tier theater missile defenses is the fact that their effectiveness may be undermined by decoys or other penetration aids, and fractionated CBW payloads—countermeasures that probably can be deployed by modestly sophisticated regional adversaries. As a hedge against these responsive threats, the United States is exploring the ABL, and to a lesser extent the ABI, concepts for airborne boost-phase theater missile defense. These systems are attractive because, contrary to what one might expect, they do not pose a realistic threat to the strategic nuclear forces of any of the five major nuclear powers. Hence, they hold the promise of providing an effective theater missile defense against regional opponents without upsetting strategic stability between the major nuclear powers.

Appendix: Future Strategic Nuclear Force Structures

This appendix describes possible future strategic nuclear force structures for Russia, China, France, and Great Britain. Considerable uncertainty surrounds these projections because of economic constraints on force modernization and the changing priority assigned to nuclear forces after the end of the Cold War. Moreover, these force structures are based on extrapolations from current trends and do not take into account reactions that might occur if U.S. ballistic missile defense systems are deployed—reactions that might lead Russia to abandon the START II Treaty or cause China to substantially increase the priority assigned to strategic missile modernization. These estimates project the number of strategic warheads that likely will be operational between 2010–2015, i.e., a period during which U.S. NMD and TMD systems might be fully deployed.

Russia

Considerable uncertainty surrounds Russia's future strategic nuclear force structure because of political and economic turmoil within Russia, the uncertain outcome of Russia's defense reform, and uncertainties with respect to which arms control treaties might be in force over the next several decades. Financial constraints are likely to be the dominant factor, forcing early retirement for some strategic systems, creating maintenance problems for others, and causing delays in force modernization to replace existing systems—the bulk of which will become obsolete around the turn of the century. Moreover, it is difficult to determine how long Russia's current financial problems will last.

Russia is also in the midst of a major defense reform. Hence, it is difficult to determine the priority that will be given to strategic nuclear forces relative to other pressing defense needs. With the collapse of Russia's conventional forces, it seems plausible that Russia might place greater emphasis on nuclear force modernization to compensate for weak conventional forces. On the other hand, conventional forces are better suited to meet Russia's future security needs over the next several decades. Finally, uncertainties regarding the fate of the START II and START III treaties imply that Russian forces may not be limited by these treaties, though financial constraints will make it difficult for Russia to maintain forces much above the level allowed by the START II Treaty.

With this uncertainty in mind, this appendix describes three different future Russian strategic force structures.[44] The largest START II–compatible force Russia will be able to deploy in the 2010–2015 time frame is estimated to contain approximately 2,430 warheads.

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44 The details of these force structures can be found in Dean A. Wilkening, *The Evolution of Russia's Strategic Nuclear Force*, CISAC Report, Center for International Security and Cooperation, Stanford University, Stanford, CA, July 1998.

This force is assumed to consist of 195 silo-based and 350 mobile single-warhead ICBMs, mostly the Topol M (a modernized version of the SS-25) although a few single-warhead silo-based SS-19s might still be in the force around 2010; 16 Borey SSBNs (the new Russian missile-carrying submarine) loaded with 12 SS-NX-28 missiles (a follow-on to the SS-N-20 SLBM), each carrying six warheads for a total of 1,152 SLBM warheads; and 29 Bear-H6 plus 35 Bear-H16 bombers carrying a total of 734 AS-15 air-launched cruise missiles for a total force containing 2,431 warheads.[45] Larger START II arsenals can be obtained if one assumes more Topol M ICBMs are deployed (estimates rarely exceed 900), more Borey submarines are produced, or more than 6 warheads are deployed on each SS-NX-28 SLBM (the maximum is reported to be 12).[46]

A more likely future Russian force, assuming modest economic recovery in Russia, will consist of 195 silo-based and 205 mobile single-warhead Topol M ICBMs, 12 Borey SSBNs loaded with 12 SS-NX-28 missiles each carrying five warheads for a total of 720 SLBM warheads, and 29 Bear-H6 plus 35 Bear-H16 bombers carrying a total of 734 AS-15 air-launched cruise missiles for a total force containing 1,854 warheads.

Finally, if the economic and political conditions that currently exist in Russia persist for the next decade, then Russia may only have a force containing around 1,320 warheads. One estimate for such a force would be 90 silo-based and 110 mobile Topol M ICBMs, 8 Borey SSBNs loaded with 12 SS-NX-28 missiles each carrying 4 warheads for a total of 384 SLBM warheads, and 29 Bear-H6 plus 35 Bear-H16 bombers carrying a total of 734 AS-15 air-launched cruise missiles for a total force containing 1,318 warheads, over half of which would be bomber weapons. Russia may also maintain a smaller bomber force. Bomber production ceased in 1991, though it will have to resume around 2010 if Russia wants to retain a bomber force beyond the year 2015.

Under the START II and START III Treaties, Russia may be able to expand the number of deployed ballistic missile warheads by 800–1,850 warheads, depending on the exact force structure one assumes. This includes reloading warheads on SS-19 ICBMs previously downloaded under START II, reactivating SS-18s until their service life expires, allowing the SS-25 and Topol M ICBMs to carry three MIRVs, and increasing the number of MIRVs deployed on the SS-NX-28 SLBM to 10 warheads instead of between four to six.

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[45] Note that all SS-18s, SS-19s, SS-24s, and SS-25s will either be obsolete or must be destroyed according to the START II Treaty by 2007. The ICBM force size depends on the production rate and service life one assumes for the Topol M. This START II force assumes an annual production rate of around 50 Topol M missiles and a service life of 15 years for the road-mobile version and 20 years for the silo-based version. For more details see Dean A. Wilkening, *The Evolution of Russia's Strategic Nuclear Force*, op. Cit.

[46] For a projection that the SS-NX-28 will be able to carry 12 MIRVs see Robert Holzer, "U.S. Study: Russia, China Sub Production Flourishes," *Defense News*, February 24–March 2, 1997, p. 8. If the SS-NX-28 carries 12 warheads, Russia could not deploy more than nine Borey submarines and remain compliant with the START II SLBM warhead sublevel (1,750 warheads), not to mention START III levels. It seems unlikely that Russia will limit the size of its submarine force in this way. Therefore, a lower warhead loading has been attributed to the SS-NX-28.

The survival of Russian forces with respect to a hypothetical U.S. counterforce attack is determined by their alert posture. On generated alert 90 percent of the silo-based ICBMs are assumed to launch out from under the attack according to Russian doctrine—although this would require that Russia improve its ballistic missile early warning network, 85 percent of the mobile ICBMs are assumed to be out of garrison, 80 percent of the SSBNs are assumed to be at sea, and 80 percent of the bombers are assumed to be on strip alert (80 percent of which are assumed to penetrate the U.S. continental air defense). This alert posture is optimistic by today's standards because only about half of the current Strategic Rocket Force can be brought to combat alert status due to maintenance problems, personnel shortages, and funding constraints. However, this posture is reasonable for a future Russian force after the current transition period has passed and stable nuclear operations resume. The most debatable assumption is that 90 percent of the silo-based ICBMs would launch out from under a U.S. counterforce attack. However, this assumption does not alter the analysis much because the Russian force contains only 195 silo-based ICBM warheads. If these ICBMs do not launch out from under the attack, approximately 20 percent would survive assuming one U.S. hard-target-kill warhead is targeted at each silo.

On day-to-day alert the silo-based ICBMs are assumed to ride out the attack resulting in a survival rate of about 20 percent, two mobile ICBM regiments (18 missiles) are assumed to be out of garrison, two SSBNs are assumed to be at sea, and none of the bombers are assumed to be on alert. This leads to a surviving force of 130–200 warheads, depending on which of the three future Russian forces described in this appendix one assumes. SLBMs are not credited with a pier-side launch-under-attack capability, although Russia is capable of such alerts and the Soviet Union practiced them during the Cold War. These numbers characterize current Russian day-to-day alert operations and may fit future Russian day-to-day alert practices assuming Russia maintains low alert rates in an effort to prolong the service life of its forces.[47] On the other hand, if Russian leaders become concerned about U.S. ballistic missile defenses, they may opt for a higher day-to-day alert rate. Soviet day-to-day alert rates certainly were higher during the Cold War.

China

The future of China's strategic nuclear force is difficult to project because it depends on the economic and technological resources available, the external security environment as viewed from Beijing (including such factors as Taiwan, the U.S.-Japanese security alliance, U.S. and Russian ballistic missile defense programs, the status of India's nuclear programs, etc.), and China's commitment to international arms control agreements (e.g., the Comprehensive Test

[47] For a discussion of current Russian day-to-day alert practices see Bruce Blair, *Dealerting Strategic Forces* (Washington, DC: The Brookings Institution, 1997).

Ban Treaty).[48] Although Chinese leaders currently emphasize economic growth over military modernization, they remain committed to nuclear force modernization, albeit at a relatively slow pace.

Projecting the size of China's nuclear force between 2010 and 2015 is difficult because of the paucity of information regarding Chinese force modernization plans. Nevertheless, its nuclear force is likely to be at least the size of the current force, and may be two to three times this size.[49] China is estimated to have enough fissile material to increase its total arsenal from its current level of 300–450 weapons to approximately 600–900 warheads.[50]

China's long-range nuclear strike capability is likely to increase substantially in the next decade. China currently has two new mobile solid-fuel ICBMs under development, the DF-31 ICBM (700 kg payload and 8,000 km range), which is to replace the liquid-fuel DF-4 IRBM (2,200 kg payload and 4,750 km range), and the DF-41 (800 kg payload and 12,000 km range), which is to replace the liquid-fuel DF-5/5A ICBM (3,200 kg payload and 12,000-13,000 km range).[51] A new solid-fuel SLBM, the JL-2 based on the DF-31 ICBM, is also under development, 16 of which are expected to be deployed on each new Type 094 SSBN.[52] Several estimates place the size of the future Chinese SSBN fleet at between three to six boats after 2010, giving rise to a sea-based deterrent with 48–96 JL-2 SLBMs.[53]

Whether or not these ICBMs and SLBMs will carry MIRVs is an open question. China has been working on MIRV technology since the early 1980s but has not yet fielded a MIRVed ballistic missile.[54] This may change in the future, although the new generation of solid-fuel ICBMs and SLBMs tend to have smaller throw weights compared with the older

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48 For a discussion of these factors see Alastair Iain Johnston, "Prospects for Chinese Nuclear Force Modernization: Limited Deterrence Versus Multilateral Arms Control," op cit., pp. 548–576.

49 The current size of China's strategic nuclear force is uncertain. However, it may contain as many as 18 DF-5/5A ICBMs; 25 DF-4, 50 DF-3/3A, and 36 DF-21 IRBMs; a single Xia SSBN carrying 12 JL-1 SLBMs, which rarely leaves port due to technical problems associated with its nuclear power plant; and approximately 150 nuclear bombs carried aboard H-6, H-5, and Q-5 medium-range bombers. See Robert Norris, Andrew Burrows, and Richard Fieldhouse, *Nuclear Weapons Databook, Vol. V, British, French, and Chinese Nuclear Weapons*, op cit., p. 359; *The Military Balance: 1997/98*, The International Institute for Strategic Studies, London, p. 176; and Bill Gertz, "China Targets Nukes at U.S.," op cit., p. 1. Of these only the 18 DF-5/5A ICBMs can threaten the United States, not counting the 12 JL-1 SLBMs on the Xia SSBN. Recent reports indicate that eight new DF-5 ICBMs will be added to the arsenal by the end of the year, although these DF-5 Mod 2 missiles probably will replace older missiles and hence will not add to the overall force size. See Bill Gertz, "China adds 6 ICBMs to arsenal," *The Washington Times*, July 21, 1998, p. 1.

50 See Alastair Iain Johnston, "Prospects for Chinese Nuclear Force Modernization: Limited Deterrence Versus Multilateral Arms Control," op cit., p. 562.

51 See John Wilson Lewis and Hua Di, "China's Ballistic Missile Programs: Technologies, Strategies, Goals," op cit., pp. 9–11.

52 See *Worldwide Submarine Challenges*, U.S. Office of Naval Intelligence, February 1997, p. 22.

53 See *Worldwide Submarine Challenges*, op cit., p. 23; and Alastair Iain Johnston, "Prospects for Chinese Nuclear Force Modernization: Limited Deterrence Versus Multilateral Arms Control," op cit., p. 562.

54 See James A. Lamson and Wyn Q. Bowen, "'One Arrow, three stars': China's MIRV programme, Part II," op cit., p. 266.

liquid-fuel missiles (i.e., 700–800 kg compared with 2,200–3,200 kg), which makes them less able to carry multiple warheads. Nevertheless, according to one estimate, the DF-41 may carry three MIRVs.[55]

Finally, the Chinese medium-range bomber leg may be phased out in the future because no new medium-range bombers are under development at the current time—presumably due to their relatively low priority, although air and sea-launched cruise missiles may appear.[56] However, China appears committed to modernizing its tactical air force with the addition of the nuclear-capable H-7 fighter-bomber.[57]

Hence, the Chinese missile force in 2010–2015 may contain eight DF-5 Mod 2 ICBMs possibly carrying three MIRVs (the older DF-5/5A ICBMs should all be retired by 2010), 10–30 DF-41 ICBMs probably carrying a single warhead, 20–40 single-warhead DF-31 ICBMs, 30–50 single-warhead DF-21 IRBMs, and 48–96 JL-2 single-warhead SLBMs carried aboard three to six Type 094 SSBNs. With respect to China's future bomber force, a few (approximately 10) H-6 medium bombers carrying one to three bombs each might still be in service.[58] Otherwise, the remainder will be shorter-range aircraft, possibly carrying up to 150 bombs. This equates to a future strategic nuclear force with 86–190 nuclear weapons capable of reaching the United States, and 126–270 nuclear weapons capable of reaching Russia. This represents a significant increase in the number of strategic nuclear weapons that can reach the United States since currently only 18 DF-5/5A ICBMs have this capability, most of which cannot survive a U.S. preemptive counterforce attack.

Since the next generation of Chinese ICBMs and IRBMs will be solid-fuel, mobile missiles, they should have a much better chance (assumed here to be a probability of 0.7) of surviving U.S. or Russian counterforce attacks. The older DF-5/5A ICBMs probably would be destroyed in a counterforce attack. Moreover, depending on the acoustic characteristics of the Type 094 SSBN, a significant fraction (assumed here to be 50 percent) of these boats may survive ASW operations long enough to launch their missiles. As for China's aging medium-range bomber fleet, only one-third of the 10 H-6 bombers that may be in existence beyond 2010 are assumed to survive a Russian counterforce attack and penetrate Russian airspace. If China uses shorter-range H-7 bombers to attack Russia, this number could increase substantially, at least for attacks directed at targets along the periphery of Russia. None of the Chinese bombers have the range to strike the United States.[59]

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55 Ibid., p. 268.

56 China attempted to acquire medium-range Backfire bombers from Russia, but the sale never materialized.

57 See Robert Norris, Andrew Burrows, and Richard Fieldhouse, *Nuclear Weapons Databook, Vol. V, British, French, and Chinese Nuclear Weapons*, op cit., p. 373.

58 The H-7 is the only modern Chinese bomber under construction and will likely be reserved for theater nuclear missions and, hence, has not been counted here as a strategic bomber. See Robert Norris, Andrew Burrows, and Richard Fieldhouse, *Nuclear Weapons Databook, Vol. V, British, French, and Chinese Nuclear Weapons*, op cit., p. 368.

59 See Robert Norris, Andrew Burrows, and Richard Fieldhouse, *Nuclear Weapons Databook, Vol. V, British, French, and Chinese Nuclear Weapons*, op cit., pp. 358–396.

France

This analysis assumes that France can deploy at most four of its five L'Inflexible-class SSBNs to sea on generated alert (one is always in overhaul). Armed with the M4B SLBM carrying six warheads each, this gives France a survivable sea-based strategic force with around 384 SLBM warheads. The number of SSBNs in the French force will drop from five to four when the Triomphant-class SSBNs replaces the L'Inflexible boats around 2005, perhaps with a corresponding drop in the number of SLBM warheads. French SLBMs are believed to have the capability to carry penetration aids, including decoys, to enhance the penetration of ballistic missile defenses. The French S3D IRBMs at the Plateau d'Albion are assumed to be retired. Finally, France is assumed to have approximately 80 ASMP air-delivered nuclear weapons carried aboard the Mirage IVP, Mirage 2000N, and Super Etendard aircraft. Some of these weapons are categorized as strategic and the rest "pre-strategic" in the French lexicon. Future French modernization plans include a longer-range ASLP missile, giving the French air force greater strategic capability. In this analysis all 80 French air-delivered weapons are assumed to have the range to strike the Russian homeland, even if they cannot reach Moscow; however, only half are assumed to survive a Russian first strike and penetrate Russia's air defenses.[60]

Great Britain

Great Britain is assumed to be able to deploy a maximum of three of its four Vanguard-class SSBNs to sea in a crisis. Each SSBN is assumed to carry 16 Trident D-5 SLBMs armed with four warheads each (64 warheads per boat) because the British D-5 SLBM will be interchangeable with U.S. missiles, the latter of which will be constrained to carry only four warheads under START II. This estimate represents a lower bound on the size of the British strategic deterrent since the British government has stated that its submarines may carry up to 96 warheads per boat.[61] Not all SLBMs on a given submarine necessarily will have the same number of warheads. As with France, British SLBMs are believed to have the capability to carry penetration aids, including decoys. For example, prior to the Trident program, Great Britain developed the Polaris Chevaline SLBM which reportedly deployed two sophisticated decoys for each of its two warheads, along with other penetration aids.[62] All British air-delivered nuclear weapons are assumed to be retired around the turn of the century. Therefore, the British strategic deterrent force on generated alert is assumed to consist of at least 192 survivable SLBM warheads.

[60] See Robert Norris, Andrew Burrows, and Richard Fieldhouse, *Nuclear Weapons Databook, Vol. V, British, French, and Chinese Nuclear Weapons*, op cit., pp. 224–306.

[61] See Robert Norris, Andrew Burrows, and Richard Fieldhouse, *Nuclear Weapons Databook, Vol. V, British, French, and Chinese Nuclear Weapons*, op cit., pp. 100–120.

[62] See Robert Norris, Andrew Burrows, and Richard Fieldhouse, *Nuclear Weapons Databook, Vol. V, British, French, and Chinese Nuclear Weapons*, op cit., pp. 105–113.