Ballistic Missile Defense and Deep Nuclear Cuts

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Introduction

Ballistic Missile Defenses (BMDs) have long been recognized as having potentially important implications for reductions in nuclear weapons. The generally-accepted logic is simple: If a Country A deploys a BMD system that is extensive and effective enough to threaten the viability of Country B's nuclear-armed ballistic missile force that B relies on for nuclear deterrence, then B must be expected to take steps to preserve the capabilities of its ballistic missile force. The most direct and unambiguously effective response for B would be to enlarge its ballistic missile force to be able to overwhelm the A's defensive system. To produce such a response A's defense does not need to be large and effective enough to defend against B's entire ballistic missile force, only the part of that force that can confidently be expected to survive a first strike attack. In fact, the defense does even need to actually exist – the threat of its deployment can be enough to provoke a response.

Concerns about the prospect of future large-scale BMD deployments contributed to the rapid increase in the number of strategic ballistic missile warheads (primarily accomplished by putting multiple warheads on missiles) which began about 1970. Recognizing the danger of potential arms race and crisis instability that would be created by a nuclear offense-defense competition, the United States and the Soviet Union negotiated the 1972 Anti-Ballistic Missile (ABM) Treaty. By sharply limiting both the number of strategic BMD interceptors as well as the infrastructure necessary for the rapid expansion of the permitted small BMD systems, the ABM Treaty helped make possible the negotiation of a series of agreements which first halted the growth of and eventually significantly reduced the numbers of nuclear-armed strategic ballistic missile warheads.

In 2001, President George W. Bush entered office determined to deploy a national missile defense (NMD) system, that is, a system intended to protect U.S. territory from intercontinental-range ballistic missiles. Accordingly, in June 2002, the United States withdrew from the ABM `Treaty and began the construction of it Ground-Based Midcourse Defense (GMD) system, which it described as a limited NMD system. This NMD system became operational in 2004 and has continued to slowly expand since then.

The United States has also continued to develop and deploy several theater ballistic missile defense (TMD) systems intended to counter shorter range missiles. These systems are intended

[1] This paper has benefitted from comments on it at a luncheon discussion in Washington D.C. on March 17, 2017 organized by the project on "A Stable Transition to a New Nuclear Order" of the Judith Reppy Institute for Peace and Conflict Studies at Cornell University and from detailed comments from Judith Reppy.

to defend U.S. forces overseas as well as to defend allies and provide them extended deterrence against missile attack. The capability of several of these TMD systems to intercept longer-range strategic missiles was controversial prior to the demise of the ABM Treaty.[2]

The collapse of the ABM Treaty regime and the beginning of U.S. NMD deployments did not, however, bring an end to negotiated U.S.-Russian nuclear arms reductions. The Strategic Offensive Reductions Treaty (SORT), signed the month before the United States withdrew from the ABM Treaty, reduced both countries' strategic nuclear forces to a maximum of 2200 accountable warheads (from the previous 6000). The New START Treaty, signed in 2010, further reduced both sides to 1550 accountable warheads.

How were these reductions to these levels possible, given the logic outlined in the first paragraph above? There were two main factors at work. First, the deteriorating state of the Russian nuclear forces, together with the impoverished state of the Russian economy, would likely have resulted in reductions to levels similar to the New START limits even in the absence of any treaty.

Second, the deployment of the U.S. NMD system proceeded only very slowly toward what appeared to be quite limited objectives. The initial stated goal of 30 interceptors was not reached until 2010, and the current plan will bring the total number of interceptors to 44 by the end of 2017. The system's first large, ground-based, discrimination radar will not be operational until 2020. Even though this slow pace of deployment has been largely due to technological problems, the development of the system has appeared consistent with a limited system. In addition, the potentially strategic-capable theater missile defense (TMD) interceptors that have been deployed to date (the Army's Terminal High Altitude Area Defense (THAAD) interceptors and the Navy's SM-3 Block I interceptors) can cover only relatively small areas and thus do not serve as the basis for a defense of U.S. territory.

Both these factors which have enabled nuclear reductions either have changed or soon will change. First, projections of future Russian strategic forces indicate that Russia will likely have to prematurely retire some existing missile warheads in order to accommodate the deployment of new systems, while still staying below the New START limits.[3] Second, the U.S. NMD system seems likely to continue to expand. More important, in 2018 the United States plans to begin deployment of a new type of TMD interceptor, the SM-3 Block IIA, which has much greater capabilities against strategic ballistic missiles than existing TMD interceptors. These new interceptors ultimately are to be based both at fixed land-based sites and on roughly 80-100 U.S.

[2] In the 1990s, Russia raised concerns that higher-speed U.S. TMD systems might be capable of intercepting their strategic ballistic missiles. In 1997 Russia and the United States signed a TMD demarcation agreement that limited the testing of higher-speed TMD systems. The United States never ratified the agreement and it became moot with the end of the ABM treaty in 2002. See Lisbeth Gronlund, "Taking a Closer Look at the 'Demarcation' Agreements," *Arms Control Today*, June/July 1998, p. 36.

[3] Hans M. Kristensen and Robert S. Norris, "Nuclear Notebook: Russian Nuclear Forces," *Bulletin of the Atomic Scientists*, May/June, 2015. Online at http://www.tandfonline.com/doi/pdf/10.1080/00963402.2016.1170359.

Navy destroyers and cruisers. Deployed off U.S. coasts, they would likely have capabilities to intercept Russian strategic missile warheads similar to those of the interceptors of the current U.S. NMD system. However, as discussed in this paper, they will be deployed in much greater numbers, potentially exceeding 500 interceptors by the mid-2030s. Most of these interceptors could be rapidly positioned to cover U.S. territory.

When it signed the New Start Treaty in April 2010, Russia signaled its concerns with potential future U.S. missile defense deployments. At that time, Russia had nearly fifty times more strategic nuclear ballistic missile warheads than the United States had strategic-capable ballistic missile defense interceptors. Despite this lop-sided ratio of warheads to interceptors, Russia made a (non-binding) unilateral statement stating its view that the Treaty "… may be effective and viable only in conditions where there is no qualitative and quantitative build-up in the missile defense capabilities of the United States."[4]

If the future U.S. ballistic missile defense program evolves as outlined in this paper, it will present a severe problem for future nuclear arms reductions. It might be possible to persuade Russia to agree to another round of modest reductions, perhaps to 1,000 strategic warheads. Even at that point, however, the number of survivable, second-strike Russian strategic ballistic warheads could be comparable to or even less than the number of U.S. strategic defense warheads (assuming half of the offensive warheads are considered survivable). While there is nothing magic about equality of numbers of warhead and interceptors, such a development would likely have an enormous psychological impact. Today, such a situation would certainly be unacceptable to U.S. leaders if the roles were reversed, and there is no reason to believe Russian leaders would think differently.

Without a fundamental change in U.S.-Russia relations, and specifically in the roles nuclear-armed ballistic missiles play in their relationship, it will be essentially impossible for them to achieve deep cuts in their strategic nuclear forces in the presence of large scale deployment of strategic-capable BMD systems. (For specificity, deep cuts are here taken to mean a reduction to 200 strategic nuclear warheads.) If these BMD deployments have any effect at all on the size of strategic offensive nuclear missile forces, it will likely be a drive to larger numbers, particularly in the case of China.

The Role of Nuclear Ballistic Missiles Today

While the United States and Russia have significantly reduced their strategic nuclear forces from the Cold War peak, nuclear armed ballistic missiles remain essential to their national security plans. The United States has embarked on an extensive nuclear modernization program that is

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[4] U.S. Department of Defense, "New Start: Article-by-Article Analysis Unilateral Statements," no date. Online at http://www.acq.osd.mil/tc/treaties/NST/Art%20By%20Art/art_uni_statements_annex.htm.

expected to cost about $350 billion over the next decade.[5] Included in this modernization plan are a new land-based intercontinental ballistic missile (ICBM) and a fleet of new ballistic missile submarines. Many of the current U.S. ICBMs and submarine-launched ballistic missiles (SLBMs) remain on high alert, ready to be launched within minutes.

Russia is similarly modernizing its strategic nuclear forces, replacing its Soviet-era ICBMS with new ones and deploying new ballistic missile submarines. As noted above, as a result of this modernization effort, it is now believed that Russia will likely have to reduce the number of warheads on some of its ballistic missiles in order to meet the new START limits. China is flight-testing a new road-mobile ICBM with multiple warheads and continues to develop and expand its small force of ballistic missile submarines.[6]

Although the U.S. modernization, in particular, is producing additional hard target killing (counterforce) capabilities,[7] the key capability underlying both the United States and Russia's nuclear deterrence policy is a reliable capability to inflict unacceptable damage on any adversary that might be considering attacking it, and the key weapons relied on for this purpose are strategic nuclear-armed ballistic missiles. So long as this remains the case, and the modernizations cited above suggest it is likely to be the case for decades at least, then a large-scale deployment of strategic-capable BMD systems will provoke responses that will make reducing nuclear weapons deployed on ICBMs and SLBMs more difficult.

In other words, to avoid provoking an offense-defense competition, countries must give up their reliance on nuclear-armed ballistic missiles for deterrence, *before* deploying extensive strategic-capable BMD systems. There is at present no indication that the United States, Russia, China, or any other country armed with long-range nuclear ballistic missiles is willing to even consider giving up its reliance on these missiles for deterrence.

Proposals for further reducing nuclear weapons generally envision a step-by-step approach in which nuclear weapons are gradually reduced, thereby contributing to a trend towards better relations between the nuclear-armed states.[8] The improving relations in turn enable further reductions in nuclear weapons, and so on, until low levels of nuclear weapons or even their

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[5] Hans M. Kristensen and Robert S. Norris, "Nuclear Notebook: United States Nuclear Forces, 2017," *Bulletin of the Atomic Scientists*, vol. 73, no. 1 (2017): pp. 48–57. Online at http://www.tandfonline.com/doi/pdf/10.1080/00963402.2016.1264213?needAccess=true.

[6] Hans M. Kristensen and Robert S. Norris, "Nuclear Notebook: Chinese Nuclear Forces, 2016," *Bulletin of the Atomic Scientists*, vol. 72, no. 4 (2016): pp. 205–211. Online at http://www.tandfonline.com/doi/pdf/10.1080/00963402.2016.1194054?needAccess=true.

[7] Hans M. Kristensen, Matthew G. McKinzie, and Theodore A. Postol, "How Nuclear Force Modernization is Undermining Strategic Stability: The Burst-Height Compensating Fuze," in preparation.

[8] See, for example, Nancy Gallagher, "Re-Thinking the Unthinkable: Arms Control in the Twenty First Century." *Nonproliferation Review* vol. 22, no. 3–4 (2015): 469–98 and Harald Müller, "Icons off the Mark: Waltz and Schelling on a Perpetual Brave Nuclear World." *Nonproliferation Review*, vol. 20, no. 3 (2013): 545–565.

abolition is achieved. This last step is generally assumed to take place in a world with much more tranquil international relations than today, a world that would likely be at least several decades in the future. However, injecting large-scale deployments of strategic-capable defenses into this process before countries have abandoned their reliance on nuclear-armed missiles for deterrence can halt or even reverse the process.

Can Deep Nuclear Cuts and Strategic BMD Systems Coexist?

There are several possible future worlds in which deployments of strategic ballistic missile defenses could be compatible with deep nuclear reductions or even with nuclear abolition.

At one end of a spectrum of missile defense deployments are worlds in which strategic BMDs are deployed but are very sharply limited. For example, if the United States halted its GMD national missile defense system at the 30 interceptors planned at the beginning of the Obama Administration, did not develop strategic-capable theater missile defense systems such as the SM-3 Block IIA, and gave strong assurances that it did not plan further expansion of these defenses, then such a system might not block further U.S.-Russian nuclear arms reductions, assuming relations between the two countries improved to the point that they would be willing to consider such reductions. Russia might seek to obtain U.S. assurances on the non-expansion of the system in the form of a legally-binding treaty, which would be politically unacceptable today but might be possible in the future.

Many supporters of the U.S. BMD program would claim that this is in fact the situation today, arguing that the GMD national missile defense system is indeed a limited system (at 44 rather than 30 interceptors) and that U.S. TMD systems are only aimed at and effective against North Korea and Iran and thus should not be of concern to Russia or China. As will be discussed subsequently, however, the currently planned capabilities of U.S. TMD systems and of the overall U.S. Ballistic Missile Defense System go far beyond just addressing the potential threat from North Korea or Iran.

Another example of such a world would be one in which defenses are deployed which are unambiguously incapable of threatening the ICBM forces of Russia or China. For example, there have been a number of proposals to build land-, sea-, or air-based boost phase systems. The Missile Defense Agency has previously started and cancelled two such programs, the Airborne Laser and the Kinetic Energy Interceptor, and has a new drone-based laser system under development. In principle, such systems, if they prove workable, could counter missile launches from relatively small countries such as North Korea (and with somewhat more difficulty, likely Iran), but could not reach deeply enough into the interior of large countries such as Russia or China to threaten their ICBM forces, although they could potentially be a threat to their SLBM forces.

A third possible world of this type would be one on which ballistic missile defenses are deployed only as point defenses protecting offensive nuclear forces.

At the other end of the spectrum are possible future worlds in which BMD systems dominate offensive forces. In such a world, defenses are deployed that are so highly effective and extensive that countries are confident of their ability to defeat any nuclear missile attack. As one study from 1987 argued, "Presumably if both the Soviet Union and the United States possess fully deployed, perfect (leak-proof) defences this situation would be stable with respect to the outbreak of nuclear war. (One might be less sanguine about the prospects for the outbreak of conventional war.)"[9]

A final possible world would be one without nuclear-armed ballistic missiles or without any nuclear weapons at all. In such a world there would seem to be little need for ballistic missile defenses, and a number of authors have argued that the elimination of offensive ballistic missiles should be coupled with the elimination of BMDs.[10] Others have argued that in a such a world ballistic missile defenses could play a stabilizing role.

Claims that deep cuts and BMD are compatible. Some analysts argue that extensive missile defense deployments are not only compatible with deep nuclear reductions (or even the elimination of nuclear weapons), but that defenses will actually help achieve such reductions. Their reports, however, assume that either that a world order has been achieved in which nuclear deterrence is no longer relied on or that defenses would be so limited that they could not threaten even greatly reduced nuclear missile forces (or both). Several examples:

(1) A 1995 report from the Stimson Center concluded that in a phased nuclear reductions process: "During phase II, if not before, the United States and the other nuclear states might also wish to deploy defensive systems capable of providing reasonably high confidence of defending successfully against small attacks. This phase would signal a key turning point in the transition from a system in which national security is founded on mutual assured destruction to a regime based on new principles of national and international security, in which defensive systems played a more prominent role."[11]

This transition to a defensive-oriented world, however, would be made possible only by a fundamental change in reliance on nuclear deterrence: "As long as the great powers had come to perceive nuclear deterrence as unnecessary to preserve stability in their mutual relations, the shift to a defensive – dominant system should be feasible."[12]

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[9] Dean Wilkening, Kenneth Watman, Michael Kennedy and Richard Darilek, "Strategic Defenses and First-Strike Stability," *Survival*, vol. 29, no. 2 (March/April 1987), pp. 137–165.
[10] Tom Sauer, "Nuclear Elimination With or Without Missile Defence?," *Cambridge Review of International Affairs,* Vol. 25. No. 3 (September 2012), pp. 433–450.
[11] The Henry L. Stimson Center, "An Evolving US Nuclear Posture: Second Report of the Steering Committee, Project on Eliminating Weapons of Mass Destruction," Report No. 19, December 1995, p. 29.
[12] Stimson Center, "An Evolving US Nuclear Posture," p. 29.

(2) In 1999, Michael Krepon argued that: “Deep cuts and defenses can be compatible and stabilizing as long as they are pursued cooperatively.” “It is time to stop pitting defenses against deep cuts.”[13]

Krepon’s article discusses only “limited” defenses that would be too small to threaten a Russian force of “several hundred strategic warheads.”

(3) Similarly, Dean Wilkening argued in a 2011 paper that: “The transition from an offence – dominant strategic balance to one dominated by defences can be managed without significantly disrupting strategic stability. Ballistic Missile Defence will, in fact, be essential for stabilizing a world without ballistic missiles just as defenses in general (ballistic-missile defence, air defence, coastal and border defence) help stabilize a world where nuclear weapons are eliminated entirely.”[14]

However, the paper finally concludes that this transition would occur at a time of tranquil relations: “This transition would occur at a time of tranquil political relations between those states with the most counterforce potential, currently the United States and Russia.”

(4) In 2008, George Perkovich and James Acton wrote: “If reliable testing convinces impartial observers that ballistic-missile defences would be highly effective in real-world scenarios, this technology could make nuclear disarmament more feasible, by ensuring against the risk of cheating and nuclear threats involving low numbers of weapons.”[15]

This conclusion applies to a world in which countries no longer pose severe threats to each other: “In a situation in which Russia and China still fear that the US (and each other) could threaten their core security interests, the more extensive and effective ballistic-missile defences are, the less likely these countries will be to reduce their offensive nuclear systems to low levels.

(5) A 2012 Global Zero report states that: “In the context of such reduced reliance on offensive nuclear weapons on launch-ready alert, the United States would increase its reliance on missile defenses and advanced conventional forces in an integrated new strategy.”[16]

The missile defenses envisioned in this report are limited to defenses capable of dealing only with the first 24–72 hours of an attack from North Korea or Iran. The report states that this could be accomplished with an EPAA system scaled down by 10% to 50%.

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[13] Michael Krepon, “Missile Defense: Not Such a Bad Idea,” *Bulletin of the Atomic Scientists*, May/June 1999, pp. 31–33.
[14] Dean A. Wilkening, “Nuclear Zero and Ballistic-Missile Defence,” *Survival*, vol. 52, no.6 (December 2010-January 2011), pp. 107–126.
[15] George Perkovich and James M. Acton, “Abolishing Nuclear Weapons,” Adelphi Paper 396, The International Institute for Strategic Studies, August 2008, p. 27.
[16] James Cartwright, Richard Burt, Chuck Hagel, Thomas Pickering, Jack Sheehan and Bruce Blair, *Modernizing U.S. Nuclear Strategy, Force Structure and Posture*, Global Zero U.S. Nuclear Policy Commission, May 2012.

However, the United States is already planning on moving far beyond limited BMD deployments, and defense dominant worlds involving a much more tranquil world order are remote, with significant and unsolved issues regarding stability on the paths to reaching these worlds. How this more tranquil world order is to be achieved, and what role BMD would play in reaching it, is not discussed in reports such as those above.

In particular, reaching any of these defense-dominant worlds requires countries to give up the capability to deter an adversary by threatening it with massive destruction by nuclear-armed ballistic missiles. Further, as discussed above, they must give up this capability *before* large-scale BMD deployments take place. Otherwise the BMD deployments will pose a threat to the still-highly-valued ballistic missile forces and provoke efforts to bolster these forces. Almost all studies of deep nuclear cuts acknowledge that reaching low levels of nuclear weapons will be a slow, long-term process, requiring several decades or longer. It now appears likely that significant levels of strategic capable BMD will be deployed with the next decade or two, potentially blocking the path to deep cuts before much progress can be made down that path.

The U.S. GMD National Missile Defense System

The United States currently operates a GMD national missile defense system that is intended to intercept intercontinental-range missiles fired at U.S. territory, including Hawaii and Alaska. The interceptor missile for the GMD system is the large Ground-Based Interceptor (GBI), each of which is armed with single infrared-homing, hit-to-kill Exo-atmospheric Kill Vehicle (EKV). Deployment of GBIs began in the summer of 2004, and by 2010 a total of 30 GBIs were deployed. In 2013, the Department of Defense announced that the number of GBIs would be increased to 44 by the end of 2017. At that point there will be 40 GBIs at Fort Greely in Alaska and four at Vandenberg Air Force Base in California.

The GBIs are supported by a network of large phased-array radars at Shemya in the Aleutians, in California, in Greenland, and in Britain. Additional radars in central Alaska and on Cape Cod are expected to be incorporated into the GMD system in 2017. Although these are large and powerful radars capable of tracking many targets simultaneously, they have little capability to discriminate actual warheads from decoys or other objects. For discrimination, the Missile Defense Agency (MDA) has built a single large radar on a modified ocean-going oil drilling platform. The radar, known as the Sea-Based X-band (SBX) radar, operates out of Honolulu and has sailed west on several occasions to observe anticipated North Korean missile flight tests. The GMD system is supported by a highly effective space-based infrared missile launch early warning system. This system, comprised of new Space-Based Infrared System (SBIRS) satellites and older Defense Support Program (DSP) satellites, detects the bright flame produced by the missile's booster rocket. A large number of smaller, forward-based radars also feed data into the GMD System.

Despite all this equipment, the capacity of the GMD system – the number of incoming warheads it can attempt to counter – is quite small. Although details of the firing doctrine for the GMD system are classified, it appears that the current plan is to fire about four GBIs at each incoming warhead in order to get a high enough probability of destroying the warhead. Thus the capacity of the system would be about 11 warheads when the 44th GBI is deployed by the end of 2017. Although it would be possible to spread out the GBIs against more targets (and this certainly would be done if more than 11 warheads were approaching simultaneously), doing so would significantly decrease the chances of destroying any given target.

The low capacity of the GMD system is primarily due to the unreliability of the GBI interceptors, which have failed in roughly half of their intercept tests, but also due to other factors, such as sensor limitations. According MDA Director Vice Admiral James Syring, MDA plans to improve the GMD system's "Homeland Defense Capabilities" by a factor of about 12 times over the next dozen years, as illustrated in Figure 1.

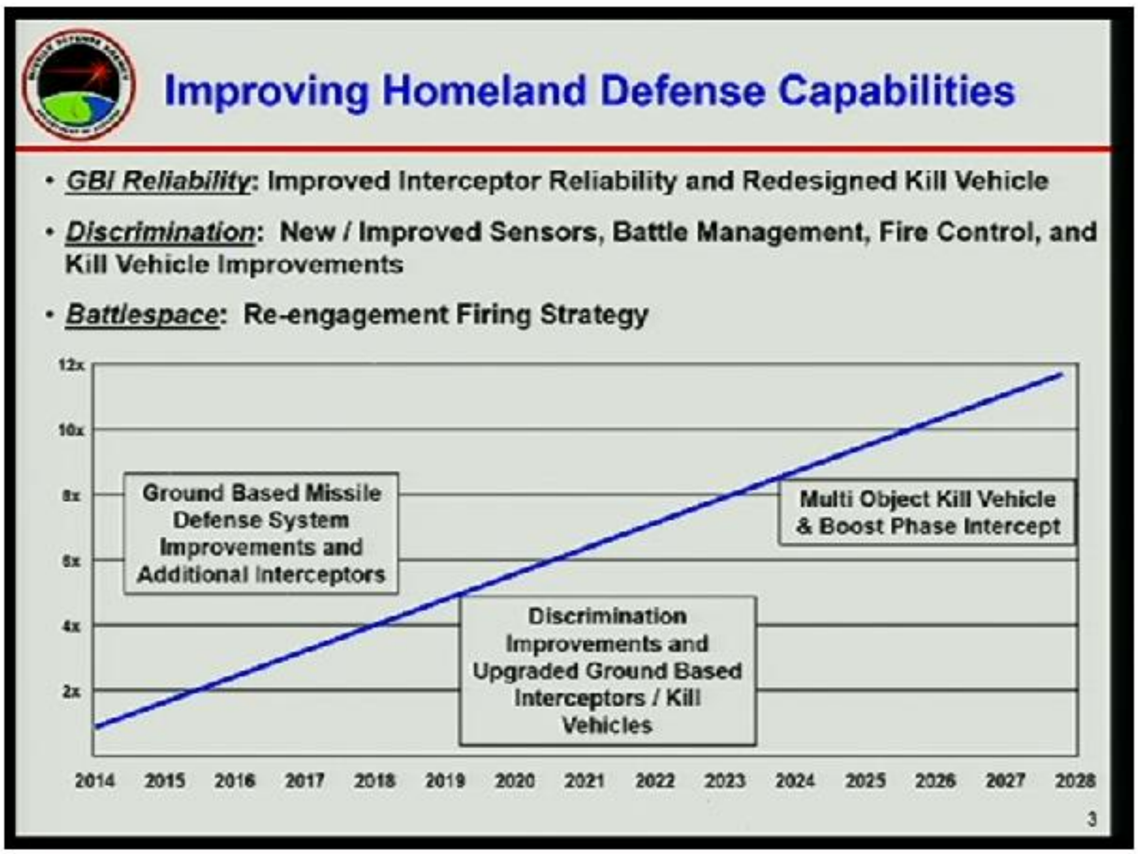

Figure 1. Planned GMD System Improvements.[17]

[17] Figure from Vice Admiral James Syring, "Update on the U.S. Ballistic Missile Defense System," Presentation at the Center for Strategic and International Studies, January 19, 2016. Online at https://www.c-span.org/video/?403405-1/discussion-ballistic-missile-defense.

This planned twelve-fold improvement is to be obtained by several steps, including:

• The replacement of the existing EKV kill vehicles on the GBI interceptor missile with a new, and hopefully much more reliable, Redesigned Kill Vehicle (RKV).

• Following the deployment of the RKVs, deployment of multiple small kill vehicles on the GBI interceptors, to counter possible decoys.

• Discrimination improvements, such as the deployment of a new Long-Range Discrimination Radar in Alaska by 2020.

• Beginning in 2020, deployment of a new, more reliable booster rocket for the GBI. This new booster will also provide the option not to fire one of its three rocket motors in order to obtain a shorter burn time. The shorter burn time will enhance the ability of the GMD system to use firing strategies, such as shoot-look-shoot, which allow more efficient allocation of interceptors against targets.

Beyond these planned improvements, there is a significant probability that MDA will deploy a third interceptor site in the eastern part of the United States.[18] Three sites—in New York, Ohio, and Michigan—are under consideration and an environmental impact study has been completed for each of them. The final site selection decision is not expected until late 2017. MDA has repeatedly stated that a third site is not needed, but it has been directed by Congress to select a site and plan for a deployment. An initial deployment would include at least 20 interceptors, and possibly as many as 60.[19] The site would take five years to build and would cost $3.6 billion for the minimum deployment of 20 interceptors.

Thus, within the next ten to fifteen years, the US GMD national missile defense system might grow to be as large as roughly 100 interceptors with significantly improved reliability relative to the system today. This might not be a large enough system to prevent a next round of future US-Russian nuclear reductions, but it could be a serious concern for China.

Strategic Defense and SM-3 Block IIA Missiles

A much more serious problem for future strategic nuclear arms reductions is likely to be the large-scale US deployment of strategic capable naval interceptors, in particular, the SM-3 Block IIA missile.

The U.S. Navy currently has 22 cruisers and 63 destroyers equipped with the Aegis combat system, which includes the Aegis computers and software, the four-faced SPY-1 phased-array

[18] Union of Concerned Scientists, "Why a Third Missile Defense Site Does Not Make Sense," Backgrounder Paper, Online at http://www.ucsusa.org/sites/default/files/attach/2017/01/East-Coast-Missile-Sites.pdf?_ga=1.237806210.302736040.1449163685.
[19] The environmental impact studies considered deployments of up to 60 interceptors.

radar, and a large number of vertical launching tubes (90-96 in the destroyers, 122 in the cruisers). In addition to BMD interceptors, the vertical launchers carry a mix of weapons including SM-2 anti-aircraft missiles, SM-6 long-range anti-aircraft missiles (which can also attack surface targets), Tomahawk land-attack cruise missiles, and anti-submarine weapons. For a number of years the Navy has been upgrading these ships to give them ballistic missile defense capabilities. Currently five cruisers and about 30 destroyers have received some form of BMD upgrade; only a few, however, have what the Navy calls the "advanced" BMD capability, which allows them to perform ballistic missile defense and air defense simultaneously. At present, the Navy is upgrading ships to the advanced capability at a rate of about two per year. In addition, all new construction destroyers will be delivered (also at about two per year) with the advanced BMD capability built in.

According to the Navy, its current requirement for ships with the advanced BMD capability is 40: four for the European Phased Adaptive Approach (EPAA) system, nine for forward deployment in Japan, and 27 for carrier battlegroups.[20] The Navy estimates that under its current plans, this requirement for 40 advanced capability BMD ships will not be met until 2026. The number of Aegis BMD ships requested by the regional combatant commanders is even higher, having grown from 42 in FY 2014 to 77 in FY 2016.

Until late last year, the Navy force structure objective for large surface combatants (destroyers and cruisers) was 88, a number that it planned to reach in the early to mid-2030s.[21] Almost all these ships are likely to be equipped with the advanced BMD capability.[22] However, in December 2016 the Navy increased its force structure goal from 308 ships to 355 ships, an increase that will likely result in the deployment of about 16 additional cruisers and destroyers.[23]

The BMD interceptors currently deployed on Aegis BMD ships are the SM-3 Block IA and SM-3 Block IB missiles. These missiles are kinematically similar, with a burnout speed believed to be about 3 km/second. After their booster burns out, above the atmosphere, these interceptors release a small-infrared-homing kill vehicle that attempts to destroy its target in a direct high-speed collision. Although these interceptors work in exactly the same manner as the GBIs of the national missile defense system, their much lower speed prevents them from being used to cover enough territory to be useful for strategic defense. Aegis ships are also equipped with modified SM-6 long-range air defense interceptors that can be used to intercept ballistic missiles within the atmosphere. However, the area these much slower interceptors can cover is even smaller than that for the Block I interceptors.

[20] Numbers in this paragraph are from Ronald O'Rourke, "Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress," CRS Report 33745, November 10, 2015, pp. 14–15. Online at http://fas.org/sgp/crs/weapons/RL33745.pdf.

[21] In most of the years between now and then, the number of cruisers and destroyers would actually exceed 88, but the number of ships would eventually decline as the cruisers are retired.

[22] Possibly only the three Zumwalt-class destroyers, which are not equipped with the Aegis system, might be without a BMD capability.

[23] Ronald O'Rourke, "Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress," Congressional Research Service, RL32665, February 2, 2017. Online at https://fas.org/sgp/crs/weapons/RL32665.pdf.

In 2018, however, the US plans to begin deployment of the new SM-3 Block IIA interceptor. This interceptor will have a much higher burnout speed of about 4.5 km/s. This higher speed after burnout enables it to cover much larger geographic areas, particularly when deployed near the target area, so that the interceptor has more flight time available.

Several published analyses have argued that Block IIA missiles have little in the way of strategic capabilities; in particular, they claim that the missiles will have little or no capability to intercept Russian ICBMs launched toward the United States.[24] However, these studies only consider Block IIA deployments as part of the EPAA system in Europe and its surrounding waters. They do not consider deployment scenarios in which the Block IIA interceptors would have potentially significant capabilities against intercontinental-range missiles, as when the ships carrying the interceptors are deployed close to U.S. territory.

U.S. Navy ships equipped with Block IIA interceptors will be distributed globally. For example, the four Aegis destroyers forward deployed to Europe as part of the EPAA are only 11% of the United States' current roughly 35 BMD capable ships, a figure that will fall to 10% by 2020 and ultimately to only 5% or even less, as more BMD capable ships become operational. The majority of U.S. BMD capable ships are and will be based at U.S. ports. Moreover, BMD ships can be rapidly deployed to new locations. As stated in April 2016 in Congressional testimony about U.S. regional missile defenses: "Our focus is on developing and fielding missile defense capabilities that are mobile and relocatable, which allow us to address crises as they emerge."[25] All of these ships can be supported by the global sensor network of United States' integrated Ballistic Missile Defense System (BMDS) that spans the entire northern hemisphere. According to the Missile Defense Agency (MDA), BMDS radars can carry out observations in 20 of the world's 24 time zones.[26]

How Many SM-3 Block IIAs Will Be Deployed?

There is little publicly-available information about how many SM-3 Block IIA interceptors the United States intends to procure. One data point is that the United States plans to buy 182 Block IIA interceptors solely for the European Phased Adaptive Approach (EPAA).[27] These missiles, to be deployed at the Polish and Romanian Aegis Ashore sites (up to 24 each) and on the four U.S. Navy destroyers now based in Spain, would support the EPAA through 2040. With a Block IIA

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[24] Joan Johnson-Freese and Ralph Savelsberg, "Why Russia Keeps Moving the Football on European Missile Defense: Politics," Breaking Defense, October 17, 2013. Online at http://breakingdefense.com/2013/10/why-russia-keeps-moving-the-football-on-european-missile-defense-politics/. Jaganath Sankaran, "Missile Defense Against Iran Without Threatening Russia," *Arms Control Today*, November 2013. Online at https://www.armscontrol.org/act/2013_11/Missile-Defense-Against-Iran-Without-Threatening-Russia.

[25] Brian P. McKeon, Principal Deputy Under Secretary of Defense for Policy. Written statement, Subcommittee on Strategic Forces, Senate Armed Services Committee, April 13, 2016. Online at http://www.armed-services.senate.gov/imo/media/doc/McKeon_04-13-16.pdf.

[26] James D. Matthewson Jr., "Missile Defense Agency, Small Business Programs Conference, Sensors Directorate Overview," August 14, 2015. Online at http://www.mda.mil/global/documents/pdf/osbp_15conf_Sensors_Matthewson11.pdf.

[27] Doubleday, "Pentagon Will Buy Extra Block IIA Interceptors."

lifetime of twelve years, not all of the missiles would be deployed simultaneously; the total deployed at any one time is likely to be between 96 and 144. It seems probable that a similar or even larger number of Block IIA interceptors will eventually be forward deployed in Japan. Currently, eleven U.S. Aegis Ships are forward deployed at Yokosuka, Japan, seven of which are BMD capable.[28] In addition, it can be expected that Japan, which is co-producing the Block IIA, will deploy a substantial number of them on its eight planned Aegis BMD-capable ships, although I do not include these in my count here.[29]

An April 2016 GAO report stated the United States planned to procure 351 SM-3 Block IIA missiles.[30] It is unlikely that this represents the actual final number, as the Missile Defense Agency has not yet even decided how many Block IB interceptors it intends to buy.[31] Moreover, 351 seems low, as it is less than twice the 182 SM-3 Block IIA missiles the United States intends to buy for just the four ships and two Aegis Ashore sites in the EPAA system, leaving on average of just 2 Block IIA missiles for the other 73 Aegis BMD ships currently requested by U.S. regional Combatant Commanders. It seems reasonable to estimate that the actual number will be at least three to four times the number deployed solely for the EPAA, or about 400–600 deployed interceptors.

Possible Mitigations

This paper has argued that, starting in the next few years, the United States will rapidly expand its strategic BMD capabilities over the next two decades. Unless a more tranquil world order, one that might allow strategic defenses and offenses to coexist without competition, is quickly established, this U.S. buildup of strategic BMD capabilities is likely to first stop and then possible reverse any further efforts to reduce nuclear weapons. Once the United States establishes a large-scale global strategic BMD system (and other nations likely deploy more limited strategic BMD systems), it is at best unclear if it will ever be possible to untangle strategic offenses and defenses and restart a process of nuclear arms reductions.

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[28] Ships at Yokusuka from "Commander Naval Surface Force, U.S. Pacific Fleet" at http://www.public.navy.mil/surfor/Pages/PacificTheaterShips.aspx#.VqFISI-cGM8, plus the Barry which replaced the Lassen in early 2016. The BMD capable ships are the Shiloh, Barry (which is an advanced BMD capability, Baseline 9 ship), Wilbur, McCain, Fitzgerald, Stethem, and Benfold.

[29] Japan currently plans to have eight BMD capable ships and has also expressed interest in deploying one or more Aegis Ashore sites. (http://news.usni.org/2015/05/18/house-paves-the-way-for-japan-to-buy-aegis-ashore-adds-anti-air-warfare-to-european-sites.)

[30] U.S. Government Accountability Office, "Missile Defense: Ballistic Missile Defense System Testing Delays Affect Delivery of Capabilities," GAO-16-339R, April 18, 2016, p. 45 (slide 32). Online at http://www.gao.gov/assets/680/676855.pdf.

[31] At the April 14, 2016 HASC Strategic Forces Subcommittee hearing, MDA Director Vice Admiral Syring, discussing the number of Block IA and Block IB interceptors, stated that "I do not have an end inventory objective yet for Aegis."

This paper does not attempt to assess how and when such a more tranquil world order might be obtained. Rather this section discusses possible "technical fixes" that might reduce the impact of U.S. missile defense deployments on nuclear arms reductions or possibly buy more time for more favorable conditions for further nuclear reductions to arise. These fixes are: (1) Reducing the ballistic missile threat; (2) Scaling back the U.S. BMD program; (3) Cooperation with Russia on BMD; (4) Greater transparency about U.S. BMD plans; (5) Incorporating BMD into nuclear arms control agreements; (6) Deployment of BMD by other countries; (7) Deployment of countermeasures to defeat BMD systems; and (8) Deployment of alternative delivery systems.

(1) *Reduce the ballistic missile threat.* If either or both nuclear and missile programs of Iran and North Korea could be shut down or greatly curtailed, then much of the justification (at least the publicly stated justification) for U.S. strategic capable BMD systems would disappear, which might allow the United States to restrain their deployments. For example, in the context of the EPAA, NATO has stated that "Of course, should international efforts reduce the threats posed by ballistic missile proliferation, our missile defence would adapt accordingly."[32] Some analysts have argued that the failure of Russia and China to take stronger steps to curtail missile and nuclear development in Iran and North Korea indicates that their concerns are not with the actual U.S. BMD program but with its implications for alliance relationships.[33]

As, however, the United States and NATO response to the successful adoption of the Joint Comprehensive Plan of Action (JCPoA) on Iran's nuclear program demonstrates, eliminating the nuclear weapons programs alone will not be sufficient to slow the U.S. BMD program. Despite Russian arguments that the JCPoA agreement eliminated the need for the EPAA program, the agreement has had no discernable effect on the plans for the EPAA, in part because it does not limit Iran's ballistic missile program.

Moreover, even eliminating both the nuclear and ballistic missile programs of Iran might not significantly impact the EPAA, because of U.S. and NATO concerns that other (unspecified) countries might deploy ballistic missiles in the future, as indicated by NATO's description of its BMD program: "NATO's missile-defense system is not directed against a single country. It is not a defense against nuclear weapons but against delivery means. It is a defense against ballistic systems that could carry nuclear, chemical, biological or conventional warheads. A workable and verifiable agreement that ensured that Iran could not develop nuclear weapons would, of course, be a great step forward. But the problem of ballistic missile proliferation will remain as pressing as ever."[34]

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[32] "NATO Deputy Secretary General Alexander Vershbow, Speech at the INSS Missile Defense Conference, Israel, January 15, 2014. Online at http://www.nato.int/cps/en/natohq/opinions_106142.htm.
[33] Participant in the March 17, 2017 luncheon discussion organized to discuss this paper.
[34] Vershbow, "Speech at the INSS." This speech was made before the conclusion of the JCPoA.

Thus, while a curtailment of the North Korean and Iranian nuclear and ballistic missile programs is highly desirable, it is unlikely to stop the U.S. BMD program, and may not even significantly slow it.

(2) *Scale back U.S. deployments or operations of strategic-capable BMD systems.* If achieving deep cuts in nuclear weapons is actually an important U.S. security objective, then the United States could consider scaling back at least some aspects of it its missile defense program to help achieve this objective. The prospects for scaling back the overall BMD program do not appear promising. U.S. BMD is a large and very well-funded program with considerable momentum. As Figure 2 shows, although the Missile Defense Agency's budget was slightly reduced under President Obama, it has remained above $7.9 billion (in FY 2016 dollars) since 2002. This seems unlikely to change without a significant change in the attitude of the U.S. Congress towards missile defense.

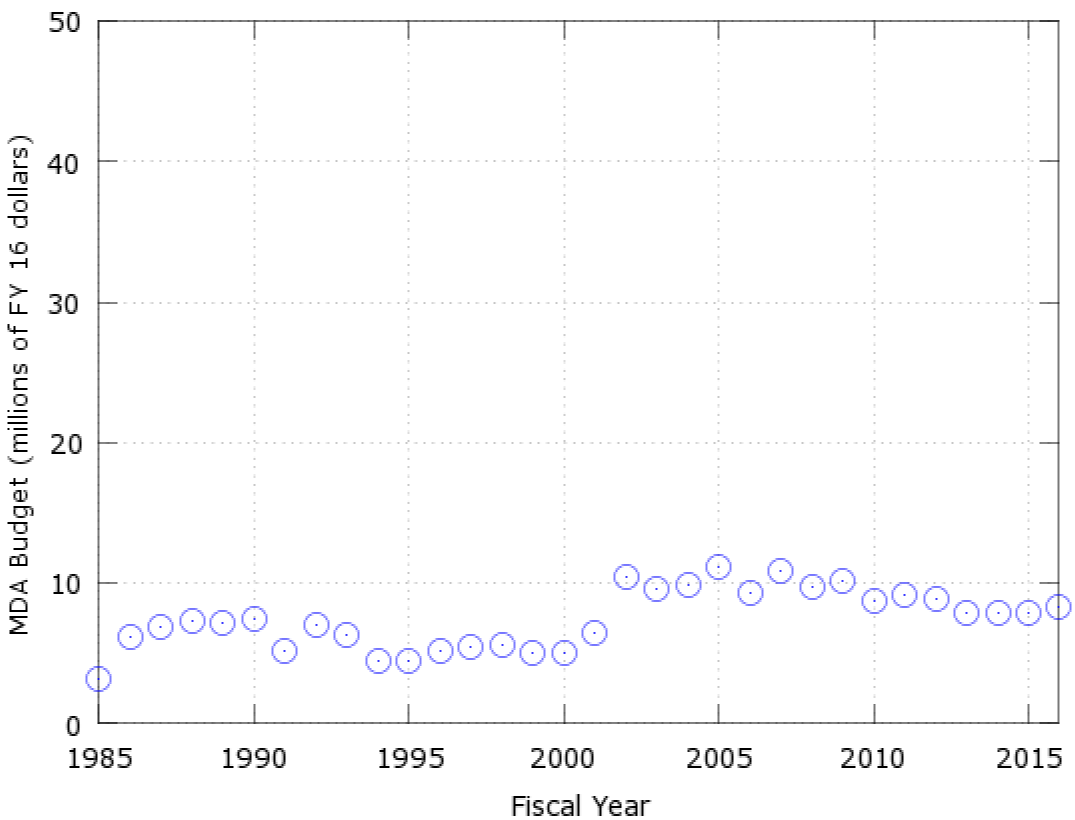

Figure 2. Missile Defense Agency (or Strategic Defense Initiative Organization or Ballistic Missile Defense Organization in earlier years) annual budget (adjusted to FY 2016 dollars).[35]

[35] Budget data from the "Appropriation Passed" column of the Missile Defense Agency chart "Historical Funding for MDA FY85-16." Online at https://www.mda.mil/global/documents/pdf/FY16_histfunds.pdf. The adjustment to FY 2016 dollars was done using U.S. Bureau of Labor Statistics, CPI Price Calculator. Online at https://www.bls.gov/data/inflation_calculator.htm.

Moreover, Figure 2 shows only the Missile Defense Agency's budget; the actual total U.S. spending on missile defense is significantly greater. For example, not included in Figure 2 is the over $1 billion per year the U.S. Army spends on the Patriot air and missile defense system, the cost of operating the four U.S. Navy destroyers based in Spain as part of the EPAA, or the estimated $18.9 billion (FY 2014 dollars) cost of deploying the new SBIRS early warning satellite system.[36]

At present, there appears to be little possibility that the United States would agree to any negotiated limits on its missile defense deployments. It might, however, be possible for it to unilaterally scale back certain aspects of its BMD program which would be most troubling to Russia and China. For example, the United States could choose not to deploy the eastern third interceptor site for its GMD national missile defense system, and keep the number of GBI interceptors capped at 44.

It would be far more important to scale back its deployments of SM-3 Block IIA interceptors (as well as any more capable successors to it). The problem here is not really the SM-3 Block IIA interceptors to be deployed at the Aegis Ashore sites in Romania and Poland or on the Aegis destroyers based in Spain (so long as they remain near European shores) as part of the EPAA. Although Russia has complained vigorously about these deployments, they do not pose a direct threat to Russian strategic ballistic missiles because these SM-3 Block IIAs are physically incapable of reaching Russian ballistic missiles on trajectories towards the United States. In addition, the deployment of the Block IIAs at these EPAA sites may be politically necessary, as the current Block IB interceptors cannot cover all the European NATO countries from these locations. Nevertheless, at least one study has suggested that the number of SM-3 interceptors deployed under the EPAA could be cut by 10% to 50%.[37]

The real problem is the large numbers of SM-3 Block IIA missiles deployed on the other 80–100 U.S. Aegis BMD ships that will be operational in the 2030s and beyond. To the extent that these missiles are intended for ship self-defense or protection of U.S. Navy carrier battlegroups, it might be possible to substitute additional SM-3 Block IBs for some of SM-3 Block IIAs. From the Navy's perspective, this substitution could have a financial advantage since a Block IB interceptor costs about half as much as a Block IIA missile. However, the much greater range of the Block IIA missile would give the Navy much greater flexibility in positioning its ships while still maintaining coverage of specific areas.

Given the current large shortfall in Aegis BMD ships relative to combatant commanders' requirements and the much greater flexibility in naval operations provided by the longer range of

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[36] SBIRS cost from Government Accountability Office, Defense Acquisitions: Assessments of Selected Weapons Systems, GAO-14-340SP, March 2014, p. 143. Online at http://www.gao.gov/assets/670/662184.pdf. Patriot data: http://www.fi-aeroweb.com/Defense/Budget-Data/FY2017/PAC-3-MSE-ARMY-PROC-FY2017.pdf.

[37] Global Zero, "*Modernizing U.S. Nuclear Strategy*." Note, however, that this report was written before the 2013 decision to eliminate EPAA Phase 4, including the even faster SM-3 Block IIB interceptor.

the Block IIA missile relative to the Block IB missile, it seems highly unlikely that the United States would restrain Block IIA numbers to levels small enough to significantly reduce the perceived threat they would present to Russia and China.

In principle, the U.S. Navy could attempt to operate its ships so as not to deploy large numbers of SM-3 Block IIAs on ships in locations from which they could defend U.S. territory. As discussed in Appendix A, the Block IIAs cannot fly high enough to intercept Russian or Chinese ICBMs at the peak of their trajectories and thus are limited to intercepting them as they descend towards their targets. This limitation means they can only attempt to defend the continental United States from locations near its coast. However, such a step would almost certainly be unacceptable to the Navy, and may not even be technically feasible, since such Block IIA missiles will be deployed on destroyers that are part of aircraft carrier battle groups, and all but one of the Navy's aircraft carriers are based in the United States. (The U.S. Navy does not change out weapons from the vertical launchers on Aegis ships except when in port.) Moreover, even if such an approach were possible, it could be quickly reversed.

One very important example of U.S. restraint would be to not develop and deploy a higher speed version of the SM-3 Block IIA interceptor, similar to the cancelled SM-3 Block IIB. (The United States does not currently have a program for such a missile.) Such a missile, with a speed similar to or higher than the cancelled Block IIB interceptor, would be capable of intercepting ICBMs and SLBMs over almost their entire midcourse trajectory. It would enable an even larger portion of the continental United States to be covered by a single ship.

It has also been suggested that the United States could limit its testing of the SM-3 Block IIA.[38] For example, SM-3 Block IIA intercept tests might be restricted only to targets with shorter than ICBM range. However, the United States believes it can readily extrapolate results from shorter-range tests to longer-range threats. As of April 2017, the U.S. GMD national missile defense system, which is a defense against ICBMs, had only tested operationally-configured interceptors against shorter-than-ICBM-range targets.

(3) *Cooperation with Russia on ballistic missile defenses.* United States-Russian cooperation on ballistic missile defenses has often been proposed as a way to mitigate the impact of U.S. BMD deployments, but little has come of these proposals. The form of U.S.-Russian missile defense cooperation that has probably come closest to realization involves sharing information collected by their early warning systems on rocket and missile launches. In September 1998, U.S. President Bill Clinton and Russian Federation President Boris Yeltsin released a joint statement stating that they had agreed to set up "an uninterrupted exchange of information on launches of ballistic missiles and space launch vehicles."[39] In June 2000, the two countries formally agreed

[38] Participant in the March 17, 2017 luncheon discussion.
[39] U.S. Department of State, Bureau of Arms Control, Verification and Compliance, "Memorandum of Agreement Between the United States of America and Russian Federation on the Establishment of a Joint Center for the

to set up a Joint Data Exchange Center (JDEC) in Moscow.[40] However, little progress was made towards establishing a working center, because of technical financial issues and Russian concerns about U.S. missile defense programs.[41] Following their meeting in Washington on June 24, 2010, U.S. President Barack Obama and Russian President Dmitry Medvedev announced that the two countries would soon start discussions on exchanging data on rocket and missile launches collected by their respective missile early warning systems. According to the U.S. State Department, other potential areas of cooperation included "joint research and development; joint missile defense testing; joint modeling and simulations; missile defense exercises; and joint analyses of alternative U.S.-Russian missile defense architectures for defending against common, regional threats."[42] There is, however, no indication that any significant successful collaboration in these areas actually occurred.

Another form of cooperation would be conducting joint assessments of ballistic missile threats. A process to conduct such assessments was set up at the Obama-Medvedev summit meeting in Moscow in July 2009. While some progress was made, the two sides were unable to agree on the threat posed by the long-range ballistic missile programs of Iran and North Korea.[43]

More recently, there have been discussions of cooperation in the context of the EPAA. Following the November 2010 NATO summit meeting in Lisbon, Portugal, the NATO-Russia Council (NRC) released a joint statement stating that: "We agreed to discuss pursuing missile-defence cooperation. We agreed on a joint ballistic missile threat assessment and to continue dialogue in this area. The NRC will also resume Theatre Missile Defence Cooperation. We have tasked the NRC to develop a comprehensive joint Analysis of the future framework for missile defence cooperation."[44]

On November 30, 2010, Russian President Medvedev, in an address to his country, stated "We will either come to terms on missile defense and form a full-fledged joint mechanism of cooperation or… We will plunge into a new arms race and have to think of deploying new strike means, and it's obvious that this scenario would be very hard."[45]

Despite several years of meetings and discussions, little came of these cooperation efforts. The two sides had greatly different objectives and were unable to overcome their differences. NATO proposed that a data fusion center be established where NATO and Russia could share intelligence and early warning data on missile threats. It also offered "full transparency" on its

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Exchange of Data from Early Warning Systems and Notifications of Missile Launches (JDEC MOA)," (no date). Online at https://www.state.gov/t/isn/4799.htm.

40 U.S Department of State, "Memorandum of Agreement."

41 Tom Z. Collina, "Russia, U.S. Working on Joint Missile Launch Notification," www.armscontrol.org, July 2, 2010. Online at https://www.armscontrol.org/act/2010_07/JointLaunch.

42 Collina, "Russia, U.S. Working."

43 Senn, "Spoiler and Enabler."

44 NATO, "NATO-Russia Council Joint Statement," Lisbon, November 20, 2010. Online at http://www.nato.int/cps/en/natohq/news_68871.htm?selectedLocale=en

45 "Russian President Warns of New Arms Race," *Washington Post*, December 1, 2010, p. A8.

future plans for and capabilities of ballistic missile defense systems.[46] NATO and Russian BMD systems would, however, otherwise remain completely independent.

Russia, on the other hand, sought legally binding assurances that NATO missile defenses would not pose a threat to Russian strategic offensive forces, a demand that was unacceptable to the United States and NATO. Russia also sought a "joint" or "sectoral" approach to European missile defense. In such an approach, illustrated in Figure 3 below, NATO and Russia would each have designated sectors of Europe which they would be responsible for defending from ballistic missile attack. To avoid Russian ICBMs on trajectories towards the United States having to fly through the sector defended by NATO, Russia sought a sector for itself that would cover several northern members of NATO. Russia also sought a prohibition on US BMD ships in the Black and Baltic seas in the North Atlantic.[47]

Figure 3. A Russian proposed sectoral approach to European missile defense.[48]

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[46] Vershbow, "The Future of Missile Defense."

[47] Natural Resources Defense Council, "From Mutual Assured Destruction to Mutual Assured Stability: Exploring a New Comprehensive Framework for U.S. and Russian Nuclear Arms Reductions," NRDC Report R:13-03-A, March 2013. p. 48. Online at https://www.nrdc.org/sites/default/files/NRDC-ISKRAN-Nuclear-Security-Report-March2013.pdf.

[48] Slide presented by Russian Chief of General Staff at Moscow missile defense conference, May 3–4, 2012. Slide posted in "Russian Strategic Nuclear Forces" blog online at http://russianforces.org/blog/2012/05/russias_sectoral_defense.shtml.

Apparently frustrated by the lack of progress in the discussions, in October 2013 Russian President Putin dissolved the Russian working group that was involved in missile defense cooperation discussions with NATO and also eliminated the position of the Russian special envoy for missile defense discussions with NATO.[49] In March 2014, following the Russian incursion into Ukraine, the United States announced that it was suspending all military-to-military (including Department of Defense civilians) dialogue and cooperation on missile defense with Russia.[50] All missile defense cooperation and dialogue remain suspended today. The Missile Defense Agency's website currently lists nineteen countries that the United States is cooperating with on missile defense (some only at the level of "missile defense discussions") and neither Russia nor China is on the list.[51]

Even if NATO and Russia were to renew discussions on missile defense cooperation in Europe this would not address issues raised by the US national missile defense system or the widespread deployment of SM-3 Block IIA interceptors at sea, which would require direct discussions between the United States and Russia on these strategic capable systems. If NATO and Russia are unable to make any progress on cooperation on missile defenses in Europe, which do not pose an actual threat to Russian strategic forces, it is hard to see how the United States and Russia will be able to succeed in discussions about systems that would pose a direct threat to Russian strategic missiles.

(4) *Greater Transparency on BMD.* It has been suggested that the United States could be more transparent about its plans for the future development of its missile defense systems in order address Russian concerns about the open-ended nature of its missile defense program. A principle Russian concern about the U.S. BMD program is that even if each individual improvement is not destabilizing, the (unknown) end state will be.[52] The plans for the EPAA, however, have been well defined for many years, yet the Russians remain quite concerned about it. In addition, the overall U.S. missile defense program is not building towards a planned objective final system, but is evolving over time: to the extent to which longer-term information about plans for the system were available, Russia might find them more frightening than reassuring.

Moreover, despite NATO's stated willingness to have full transparency on its missile defense plans with Russia, the United States is currently unwilling to share even such basic information as the speed of the interceptors. Even though the argument that the EPAA is not a threat to Russian strategic forces is in large part based on the interceptors being too slow, in a 2014

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[49] Nuclear Threat Initiative, "Putin Dissolves Task Force for Missile Defense Cooperation with NATO," October 31, 2013. Online at http://www.nti.org/gsn/article/russia-moving-deepen-air-defense-ties-ex-soviet-republics/.
[50] Nuclear Threat Initiative, "Washington Suspending Missile Defense Cooperation Talks with Moscow," March 27, 2014. Online at http://www.nti.org/gsn/article/us-suspends-antimissile-cooperation-talks-russia/.
[51] U.S. Missile Defense Agency, "International Cooperation," no date. Online at https://www.mda.mil/system/international_cooperation.html.
[52] Participant in the March 17, 2017 lunch discussion.

Congressional hearing, MDA Director Vice Admiral James Syring stated, in response to a question, that he would be unwilling to release information on interceptor speeds to Russia.[53] The fiscal year 2016 Defense Authorization Act prohibits sharing classified or otherwise controlled missile-defense information" with Russia or China and specifically prohibits sharing of "information relating to the velocity at burnout missile defense interceptors or targets.[54]

(5) *Incorporate BMD systems into nuclear arms agreements.* It might be possible to include defense interceptors in future arms reduction agreements by trading off BMD interceptors for nuclear missile warheads, perhaps in some ratio other than one-to-one.

A basic problem with such an approach is that since the United States does not see its BMD program as part of the nuclear balance with Russia, it gains nothing from such a tradeoff, which would require the United States to accept both a lower number of nuclear weapons than Russia and limits on the number of U.S. BMD interceptors. Neither of these conditions appear to be acceptable to the United States.

Moreover, such an incorporation of defenses in negotiations on strategic offensive forces does not address the fundamental tension between nuclear offense and defense. The deployment of defenses by one country that could threaten the retaliatory capability of the other country will still be unacceptable to the other country, leading it to expand or otherwise improve its offensive forces.

(6) *Russia (and China) could deploy its own strategic BMD system.* Such a system could potentially enhance the number of Russia survivable strategic missile warheads if it were deployed to defend the missile silos. However, this might at best increase the number of survivable Russian warheads by a factor of two (and likely less), and so it does not really open the way to significantly deeper reductions. On the other hand, it raises the prospect of a Cold War style offense-defense arms race, but this time without the offenses having such a huge head start.

In addition, depending on how they are structured, BMD defenses might be vulnerable to direct attack and destruction. Although the interceptors of the U.S. GMD system are housed in silos, these silos are neither sufficiently hardened nor widely enough spaced to prevent many GBIs being destroyed by a single attacking nuclear missile. The large ground-based radars that form the core of the GMD system's sensors network are also vulnerable to direct attack. If defenses are highly vulnerable to attack, then the deployment of competing defenses could be destabilizing.

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[53] Hearing of the Subcommittee on Strategic Forces, House Armed Services Committee, March 25, 2014, pp. 23–24. Online at https://www.gpo.gov/fdsys/pkg/CHRG-113hhrg87856/pdf/CHRG-113hhrg87856.pdf.

[54] U.S. Congress, National Defense Authorization Act for Fiscal Year 2016, Section 1671, online at https://www.gpo.gov/fdsys/pkg/BILLS-114s1356enr/pdf/BILLS-114s1356enr.pdf.

(7) *Countermeasures*. Critics of BMD, particularly of BMD systems that operate above the atmosphere such as those considered here, frequently argue that such defenses are vulnerable to technical steps intended to defeat the defense. Light-weight decoys are the most commonly discussed countermeasure, although there many other possibilities, such as obscuring clouds of chaff, cooled shrouds around warheads, or the use of non-standard or maneuvering trajectories.[55] In 2000, President Clinton cited the problem of countermeasures as one of the reasons for his decision to defer a deployment decision on the national missile defense system that had been developed during his administration.[56]

The debate over the potential effectiveness of countermeasures has not been settled. Although recent US tests of its GMD national missile defense system are said to have included countermeasures, the details are classified and any countermeasures actually used are likely to have been straightforward to defeat, such as balloon decoys with a different shape than the target warhead.

For every countermeasure there are potential counter-countermeasures, and it may be difficult for either the attacker or the defender to have high confidence in the effectiveness of his forces. In this situation a ballistic missile attacker facing an extensive BMD deployment will likely be reluctant to rely on countermeasures alone. Thus, countermeasures are unlikely to eliminate the dynamic in which a ballistic missile attacker feels compelled to enlarge its forces in the face of BMD deployments.

(8) *Other delivery systems.* Even if the United States were to deploy highly-effective large-scale strategic ballistic missile defenses today, Russia would still retain some capability to strike the United States with its strategic bomber force. Russia currently operates two types of long-range (heavy) bombers, with about 60 of these accountable under the New START Treaty, and it reportedly has plans to restart production of one of these bombers after 2023, as well as to develop a new type of long-range nuclear bomber.[57] Both types of bombers are capable of carrying AS-15 long-range nuclear-armed cruise missiles. Thus, instead of responding to a United States deployment of strategic-capable BMD with a buildup (or a refusal to further reduce) of its strategic ballistic missile force, Russia could instead shift greater emphasis to its nuclear bomber force, assuming the United States does not also deploy a comprehensive air defense system. Such an augmented bomber force might not replace their ballistic missile forces, but only add to them, and thus might be counterproductive to efforts to achieve deep cuts in nuclear weapons. The response of expanding its bomber force may not be satisfactory to Russia,

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[50] Kurt Gottfried, Lisbeth Gronlund, George N. Lewis, Theodore A. Postol, and David C. Wright, Countermeasures: A Technical Evaluation of the Operational Effectiveness of the Planned US National Missile Defense System (Cambridge, MA: Union of Concerned Scientists and MIT Security Studies Program, April 2000)

[56] Eric Schmitt, "President Decides to Put Off Work on Missile Shield, *New York Times*, September 2, 2000.

[57] Kristensen and Norris, "Russian Strategic Nuclear Forces, 2016," p. 130.

which has always placed greater emphasis on it strategic ballistic missile forces than its strategic bombers.

A more radical alternative delivery system approach would be to replace some or all the reentry vehicles on Russian ICBMs and SLBMs with nuclear-armed hypersonic boost-glide vehicles.[58] Russia, China, and the United States are currently testing long-range boost-glide vehicles.

A hypersonic boost-glide vehicle can be similar in size to an ICBM reentry vehicle, and thus could potentially be mounted on an existing ICBM with only minor modifications to the missile. The initial flight of a hypersonic boost-glide vehicle would also be similar to that of an ICBM, but rather than flying on a ballistic trajectory that takes it high above the atmosphere, the boost-glide vehicle flies on a lower trajectory and re-enters the atmosphere shortly after its booster rocket burns out. It then glides through the atmosphere for most of its trajectory, maneuvering using atmospheric forces before steeply diving on its intended target.

The development and deployment of intercontinental-range (greater than 5,500 km) boost-gliders faces formidable technical obstacles. In particular, the heat generated by flying through the upper atmosphere at speeds of Mach 20 or higher places tremendous demands on the structure and materials of the glider. Two tests by the United States of intercontinental-range boost-gliders failed in 2010 and 2011. However, in 2011 the United States successfully tested a hypersonic boost-glider to a range of about 3,800 km.[59] While well short of true intercontinental-range, this test suggests that such longer-range weapons may eventually be feasible.

Assuming Russia could successfully develop and deploy such intercontinental-range hypersonic boost-glide vehicles, they would be invulnerable to the GBI interceptors of the U.S. GMD national missile defense system and also to SM-3 Block IIA interceptors deployed near U.S. territory. Both the GBI and SM-3 interceptors operate above the atmosphere, which is generally assumed to mean at altitudes above 100 km, but boost-glide vehicles may fly most of their trajectories at altitudes as low as 60 km or lower.[60] The boost-glide vehicles' combination of low altitudes and maneuverability would also allow them to evade detection by the GMD system's radars. Boost-glide weapons are, however, still under development and could be years from a possible deployment. It is unclear if they could be deployed in significant numbers in time to alleviate concerns about U.S. strategic-capable missile defenses.

[58] For information on hypersonic boost-glide vehicles, see James M. Acton, *Silver Bullet?: Asking the Right Questions About Conventional Prompt Global Strike*, Carnegie Endowment for International Peace, 2013, online at http://carnegieendowment.org/files/cpgs.pdf; James M. Acton, "Hypersonic Boost-Glide Weapons," *Science and Global Security*, Vol. 23, No. 3 (2015), pp. 191–219, online at http://www.tandfonline.com/doi/pdf/10.1080/08929882.2015.1087242. (See also: James M. Acton, "Supplement to Hypersonic Boost-Glide Weapons," online at http://www.tandfonline.com/doi/suppl/10.1080/08929882.2015.1087242/suppl_file/gsgs_a_1087242_sm8006.pdf).
[59] Acton, "Silver Bullet?," p. 43.
[60] Figure 4 (p. 206) of Acton, "Hypersonic Boost-Glide Weapons," shows two simulated trajectories for intercontinental-range boost-gliders, both of which remain below 60 km after their initial phase of flight.

If, however, Russia (or China) were to succeed in the development and deployment of intercontinental-range hypersonic boost-glide vehicles, the vehicles could provide a substitute for their nuclear-armed ICBMs which could defeat all existing U.S. ballistic missile defenses with high confidence. Recently, concern has grown about the possible vulnerability of U.S. ballistic missile defense to defeat by hypersonic boost-glide vehicles. For example, the FY 2017 National Defense Authorization Act states that: "The Director of the Missile Defense Agency shall serve as the executive agent for the Department of Defense for the development of a capability by the United States to counter hypersonic boost-glide capabilities…" and that the Director will "…not later than September 30, 2017 establish a program of record to develop a hypersonic defense capability."[61] However, developing a nationwide defense against hypersonic boost-glide weapons will be neither easy nor inexpensive, as it will require developing entirely new methods of tracking and intercepting high-speed objects within the atmosphere.

One advantage of intercontinental boost-glide weapons being very high technology weapons is that they could be difficult or impossible for a country like Iran or North Korea to develop and deploy. Thus, in principle, the United States might not feel compelled to respond to such deployments of Russian or Chinese boost-glide weapons, since at least in declaratory policy, its national missile defense system is not intended to counter their missile forces. In reality, however, an unregulated deployment of such weapons by Russia and/or China seems much more likely to trigger an intense offense-defense competition.

Conclusions

The link between strategic-capable ballistic missile defenses and nuclear offensive missile forces remains strong. Although significant progress has been made in reducing U.S. and Russian nuclear forces, and their nuclear ballistic missile forces in particular, all nuclear weapon states today still rely heavily on nuclear-armed ballistic missiles in their security planning. So long as this remains the case, the deployment of ballistic missile defenses extensive enough to threaten these ballistic missile forces seems certain to provoke responses, most likely involving enlargement of these ballistic missile forces. If large-scale deployments of strategic capable BMD systems are not to derail future nuclear offensive reductions, countries must first give up their reliance on offensive nuclear ballistic missiles. No country appears ready to do so.

Although it is possible to envision strategic BMD deployments that are limited enough to permit future U.S.-Russian reductions in their offensive nuclear forces, the BMD systems the United States is currently planning and building go far beyond such limited systems. In particular, over the next 10 to 20 years United States plans to deploy 80–100 BMD capable ships armed with hundreds of strategic-capable SM-3 Block IIA interceptors integrated into a global U.S. sensor

[61] U.S. House of Representatives, National Defense Authorization Act for Fiscal Year 2017, Conference Report to Accompany S. 2943, Report 114-840, November 30, 2016, section 1687. Online at https://www.gpo.gov/fdsys/pkg/CRPT-114hrpt840/pdf/CRPT-114hrpt840.pdf.

network. This development seems likely to threaten even a modest next round of U.S.- Russian nuclear reductions, and more so, future deep cuts in nuclear weapons.

It is important to emphasize that these US missile defense deployments are happening now and in the near future. The number of US BMD capable ships will increase by about four per year over the next decade. The SM-3 Block IIA interceptor successfully completed its first intercept test in February 2017 and is scheduled to begin deployment in 2018. The path to deep cuts in nuclear weapons is usually viewed as a step-by-step process that will require considerable time, perhaps decades or more, to achieve. The U.S. missile defense program is on a trajectory that could cut off this process before even the next step can be accomplished. Once large-scale strategic BMD deployments are in place, it is at best unclear if they could ever be reversed or how an offense-defense competition could be avoided.

The United States does not regard its planned BMD deployments as either aimed at or threatening to Russia (or China) and thus is deploying them without regard to Russian concerns or reactions. While this remains the case, the United States will not unilaterally restrain its BMD deployments.

Russia and China can take measures to preserve the capabilities of their nuclear deterrents, but these measures will almost certainly make nuclear reductions more difficult. Facing a rapidly growing threat to the effectiveness of its ICBM and SLBM forces over the next ten to twenty years, it is implausible that Russian will respond by de-emphasizing the importance of its nuclear ballistic missiles. Yet this is precisely what would have to happen for large-scale deployment of strategic capable defenses not to derail deep cuts. The pace of large-scale deployments of strategic-capable defenses by the United States is likely to preclude the type of changes in thinking that are need to achieve deep cuts, particularly because at present none of the countries concerned appears to be even remotely interested in such a change of thinking.

Appendix A: Strategic Defense Capabilities of SM-3 Block IIA Interceptors

In the discussion here, the capabilities of SM-3 Block IIA missiles to defend the United States against ICBMs is broken down into two aspects; coverage -- the portion of U.S. territory the Block II missiles have the kinematic capability to attempt to defend; and kill capability – the ability of the Block IIA interceptor to home in on and destroy incoming intercontinental ballistic missile (ICBM) warheads.

Coverage

It has long been known, although perhaps not as widely understood as it should be, that if Block IIA interceptors were deployed close to U.S. territory and supported by the BMDS system's sensors, they could provide coverage of the entire United States.

Figure 1A below shows a rough coverage "footprint" from 1994 of a SM-3 Block IIA-like interceptor (then known as the Navy Upper Tier interceptor) against an ICBM flying over the North Pole. It shows that the contiguous 48 states could potentially be covered from a few off-shore launch sites.

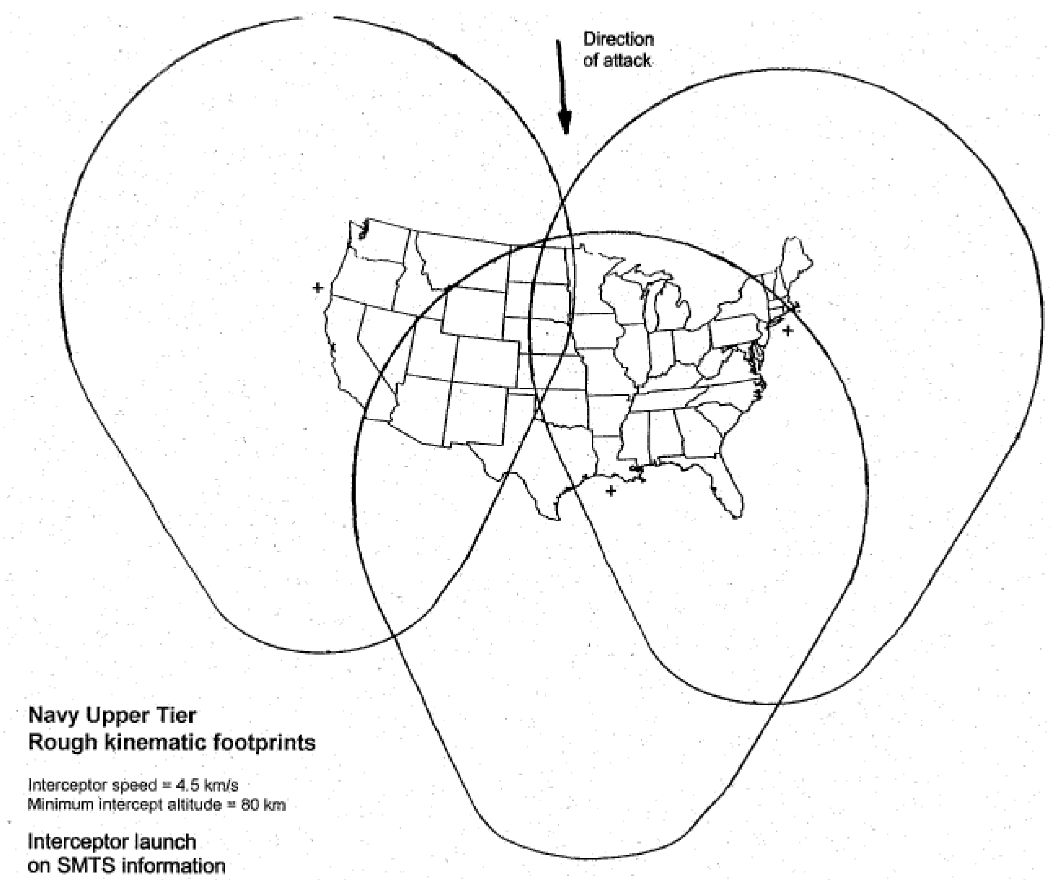

Figure 1A. Rough footprints for SM-3 Block IIA-like interceptors deployed off the coasts of the United States.[62] *The interceptor speed is 4.5 km/s, the speed typically assumed for the Block IIA.*

[62] Lisbeth Gronlund, George Lewis, Theodore Postol and David Wright, unpublished footprint, 1994.

Interceptors are assumed to be launched based on a then-planned (but never built) space-based tracking system. If the launches were instead based on the current Upgraded Early Warning Radars, the footprints would likely be somewhat smaller in the forward (northern) direction, giving footprints more like that shown in Figures 2A and 3A.

Several years earlier, the Strategic Defense Initiative Organization (SDIO) had produced a similar figure, although it was classified at the time. Figure 2A below shows a SDIO chart from 1992 (which appears to have been publicly released in 2005). It shows the coverage against an ICBM of the Navy Upper Tier interceptor. Figure 2A shows the entire contiguous 48 states could be covered from five ATBM (anti-tactical ballistic missile) sites – four just offshore and one in the Great Lakes. Today, basing a ship in the Great Lakes would not be necessary, as the central United States site (if needed) could be provided by an Aegis Ashore (AA) site similar to the ones already deployed in Romania and Hawaii and planned for Poland.

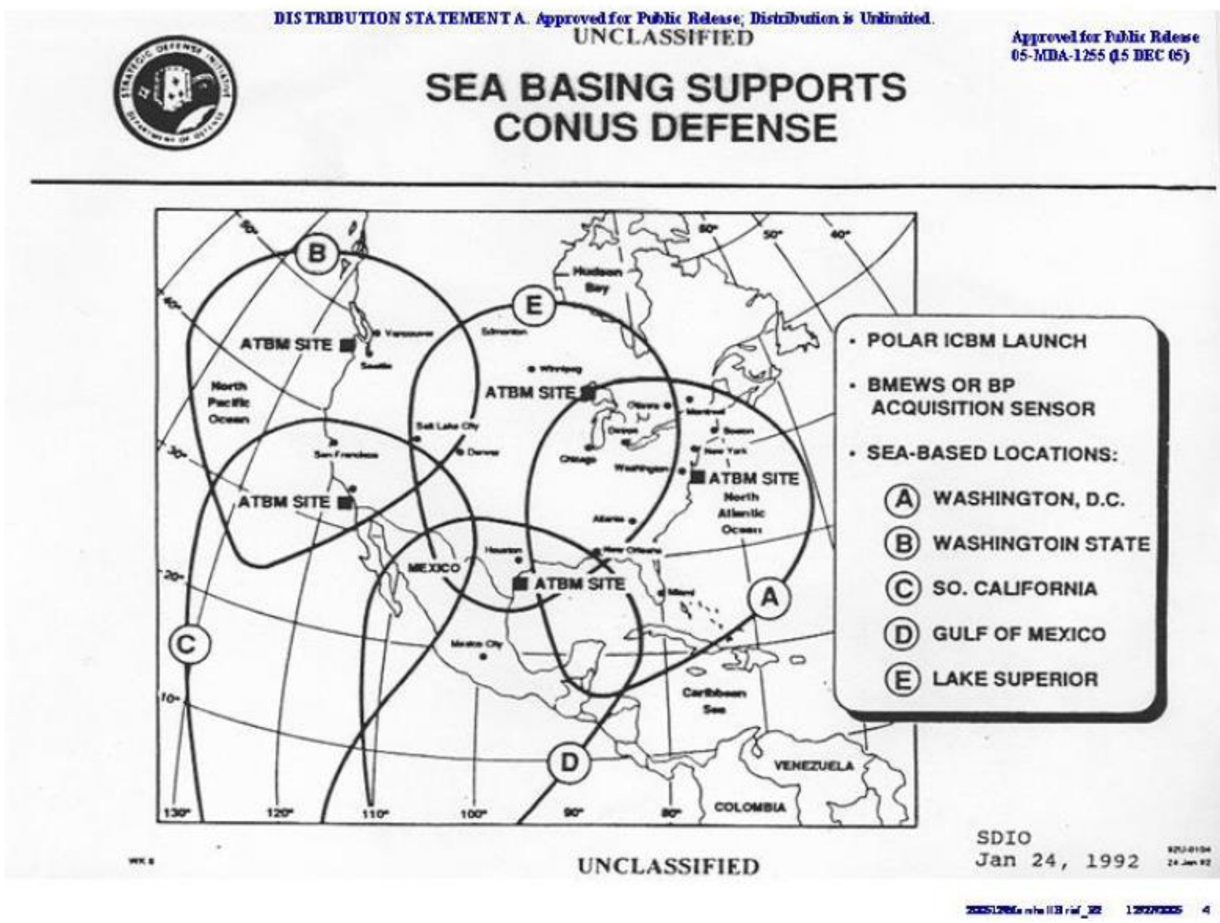

Figure 2A. 1992 SDIO figure showing coverage of the United States by a Block IIA – like interceptor. [63]

[63] Rear Admiral A. Brad Hicks, "Aegis Ballistic Missile Defense (BMD) System," Washington Roundtable of Science and Public Policy, George C. Marshall Institute, December 19, 2005. Online at

Figure 3A below shows a similar “footprint” for a single ship with SM-3 Block IIA interceptors located off the U.S. East Coast.

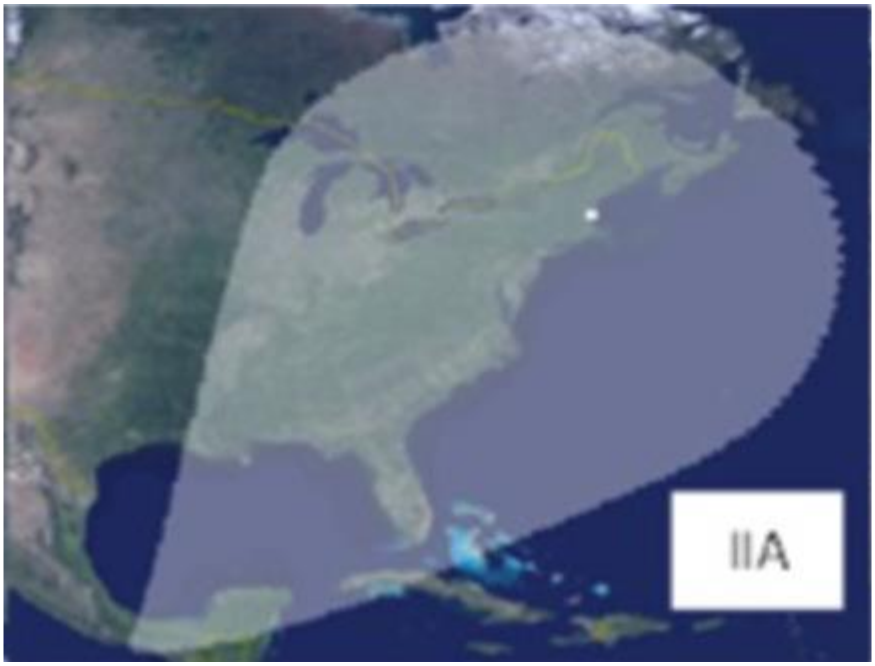

Figure 3A. Coverage of the eastern half of the United States against an ICBM from a single ship just off the coast.[64]

Figure 4A below provides a different perspective on the coverage of U.S. territory by Block IIA interceptors by showing potential intercept geometries against Russian ICBMs.

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http://marshall.wpengine.com/wp-content/uploads/2013/08/Hicks-Aegis-Ballistic-Missile-Defense-BMD-System.pdf.

[64] Sydney J. Freedberg, Jr., “Aegis Ashore: Navy Needs Relief from Land” www.breakingdefense.com, July 2, 2015, online at http://breakingdefense.com/2015/07/aegis-ashore-navy-needs-relief-from-land/. The image is attributed to retired VADM J.D. Williams and is described as being based on analysis by M.I.T.’s Lincoln Laboratory.

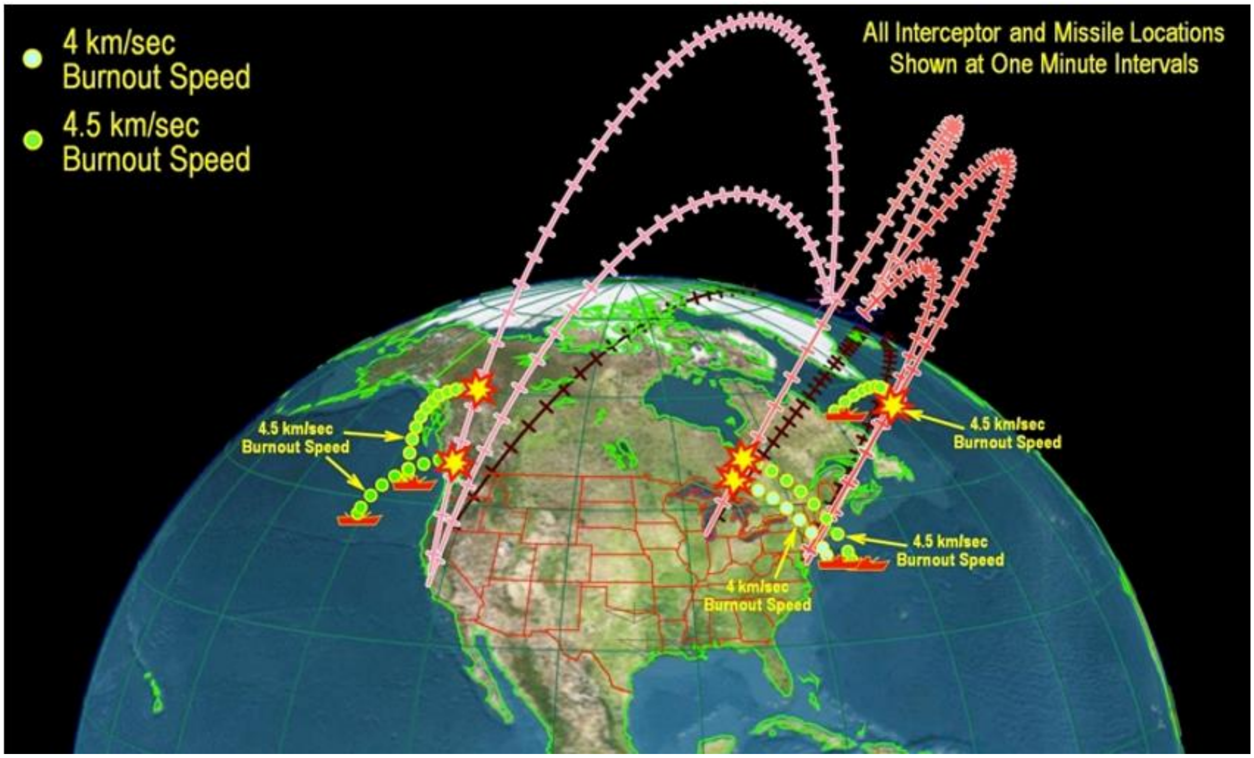

Figure 4A. Intercept geometries for Block IIA-like interceptors against Russian ICBMs.[65] The black hatched lines are the ground tracks of the missile trajectories.

The above figures make it clear that the entire contiguous United States could be covered by no more than three or four ships equipped with Block IIA interceptors, perhaps supplemented by a single Aegis Ashore (AA) site. An additional ship or AA site would be needed for Alaska; Hawaii already has an experimental AA site that could be converted to an operational site. According to one estimate, the experimental AA site in Hawaii could be converted into an operational site for $41 million.[66]

Kill Capability

Given the ability of Block IIA interceptors to cover the country from a small number of launch sites, the only thing that could prevent them from having a potential capability (leaving aside for now the problem of countermeasures that plagues any exo-atmospheric defense) against Russian

[65] Yousaf Butt and Theodore Postol, "Upsetting the Reset: The Technical Basis of Russian Concern over NATO Missile Defense, Federation of American Scientists Special Report Number 1, September, 2011, p. 24. Online at http://fas.org/pubs/_docs/2011%20Missile%20Defense%20Report.pdf. Block IIA interceptors will likely have a speed of about 4.5 km/s.

[66] Andrea Shalal, "Exclusive: U.S. Weighs Making Hawaii Missile Test Site Operational – Sources," Reuters, January 22, 2016.

and Chinese intercontinental ballistic missiles (ICBMs) would be if the Block IIA kill vehicles were not capable of homing in on and hitting the ICBM warheads.[67]

ICBMs (missiles with ranges greater than 5,500 km) have higher burnout speeds than shorter-range missiles, and intercepting them will thus often involve higher closing speeds than against shorter-range missiles, in turn requiring more capable kill vehicles. Official descriptions of the SM-3 Block IIA credit it with being able to intercept intermediate-range ballistic missiles (IRBMs, ranges between 3,000 and 5,500 km), shorter range missiles, and "some ICBMs."[68] However, there is little doubt that the Block IIA kill vehicles will be able to home in on and intercept ICBM warheads.

In February 2008, the United States used an SM-3 interceptor to destroy a malfunctioning satellite, specifically targeting a fuel tank on the satellite.[69] The satellite was travelling at a speed of greater than 7.6 km/s, a speed comparable or greater than that of an ICBM. Three years later, the United States demonstrated that an SM-3 missile can intercept an IRBM in a successful intercept test in April 2011.[70]

Both these intercepts involved only a first-generation Block IA interceptor. The Block IIA kill vehicle will be two generations in capability beyond the Block IA kill vehicle used in those intercepts. Relative to the Block IA kill vehicle, the next-generation Block IB kill vehicle adds a two-color seeker with improved optics and an advanced signal processor. The Block IB kill vehicle also has a new, "more flexible" throttleable divert and attitude control system (TDACS), which improves its divert capabilities.[71] According to reports, the TDACS is able "to dynamically vary its thrust and operating time" and provides higher thrust levels using continuous thrust management to give a greater divert capability than does Block IA kill vehicle.[72] The Block IIA interceptor will further improve on the Block IB kill vehicle by adding a "large diameter" kill vehicle with an "advanced discrimination seeker" and a "high divert DACS."[73] Relative to the SM-3 Block IB, the SM-3 Block IIA has "more than doubled seeker sensitivity" and "more than tripled divert capability."[74]

Official figures make it clear that the Block IIA is expected to be able to intercept full-range ICBMs. Figure 5A below is from a 2008 Missile Defense Agency slide that shows that the Block

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[67] This conclusion would also apply to Russian and Chinese submarine launched ballistic missiles that were launched from close to their national territory.
[68] RDML Joe Horn, "Aegis BMD Overview to the National Defense Industrial Association," July 13, 2010, slide 13. Online at http://www.ndia.org/resources/onlineproceedings/documents/0100/0100-aegisbmdoverview-rdmlhorn.pdf.
[69] Thom Shankar, "U.S. Missile Strikes Spy Satellite from its Orbit," *New York Times*, February 21, 2008.
[70] U.S. Missile Defense Agency, "Sea-based Missile Defense Flight Test Results in a Successful Intercept," News Release, April 15, 2011. Online at http://www.mda.mil/news/11news0007.html.
[71] MDA, "Second-Generation Aegis Ballistic Missile Defense System Completes Successful Intercept Flight Test," News Release, May 9, 2012.
[72] Zachary M. Peterson, "Raytheon, ATK Hope To Start Advanced SDACS Flight Tests This Year," Inside Missile Defense, August 30, 2006; "Raytheon and Aerojet demonstrate SM-3 Throttling Divert and Attitude Control System," PR Newswire US, August 15, 2006.
[73] Ballistic Missile Defense Review Report, p. 20.
[74] Department of Defense, Fiscal Year (FY) 2017 President's Budget Submission, Missile Defense Agency, RDT&E. Vol. 2a, February 2016, p. 2a-891. Online at http://comptroller.defense.gov/Portals/45/Documents/defbudget/FY2017/budget_justification/pdfs/03_RDT_and_E/MDA_RDTE_MasterJustificationBook_Missile_Defense_Agency_PB_2017_1.pdf.

IIA is able to intercept ICBMs with a full ICBM range of about 10,000 km in the descending phase of their flights – precisely the scenario illustrated in Figures 1A, 2A, 3A and 4A.

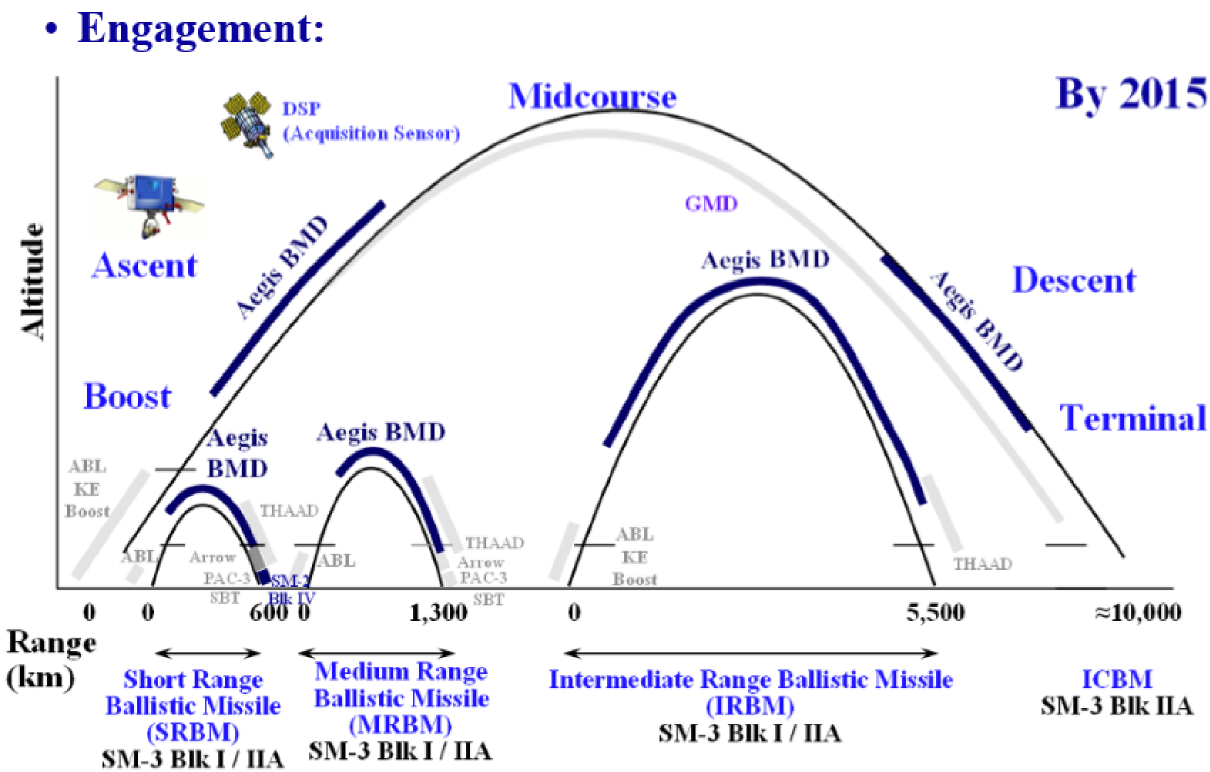

Figure 5A. MDA slide from 2008 showing Block IIA interceptors can intercept ICBMs with ranges of 10,000 km during the ascending and descending phases of their flights.[75]

A similar figure in a 2012 National Academy of Sciences Report shows the Block IIA being able to intercept an ICBM over an even greater fraction of its trajectory.[76]

The proposed plan to convert the Hawaii Aegis Ashore experimental site into an operational site also assumes an SM-3 capability against ICBMs, as Honolulu is about 7,000 km from North Korea, considerably farther than the minimum ICBM range of 5,500 km.

More generally, DOD and MDA officials have stated that they have at least considered the use of SM-3 interceptors as substitutes or supplements for the GBIs of the current U.S. GMD national missile defense system. In April 2013, in response to a question about a possible East Coast GBI interceptor site, the Chairman of the Joint Chiefs of Staff General Martin Dempsey told Congress

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[75] Missile Defense Agency, "Aegis Ballistic Missile Defense: Status, Integration and Interoperability," May 6, 2008. Online at http://www.ndia.org/Resources/OnlineProceedings/Documents/8100/AegisBMD-StatusIntergrationandInteroperability.pdf.

[76] Figure 1-2 on page 27 of Committee on an Assessment of Concepts and System for U.S. Boost-Phase Missile Defense in Comparison to Other Alternatives, National Research Council of the National Academies, *Making Sense of Ballistic Missile Defense: An Assessment of Concepts and System for U.S. Boost-Phase Missile Defense in Comparison to Other Alternatives*, 2012, shows SM-3 Block IIA missiles are able to intercept ICBMs over most of their descending trajectories. Online at http://www.nap.edu/catalog/13189/making-sense-of-ballistic-missile-defense-an-assessment-of-concepts.

that: “The only thing I would add, Mr. Secretary and Congressman, is that the environmental impact study shouldn’t be taken to assume that we will, in fact, establish an East Coast missile field for the ground-based interceptor, because we have other options. We have other options, to include sea-based.”[77]

Three months later, in response to similar question, MDA Director Vice Admiral James Syring told the Senate that: “As Chairman Dempsey has testified, that will be one of the capabilities that will be evaluated. The Aegis system, as you known, is a fantastic system. We would have to get into a classified discussion in terms of what coverage and what capability that could provide in defense of the homeland, which I’d rather not go into here in an unclassified setting. But, yes, sir, it will be a capability that we examine in conjunction with examining the third site.”[78] Note that both Dempsey’s and Syring’s statements were made after the cancellation of the SM-3 Block IIB interceptor program.

[77] Defense Subcommittee, House Appropriations Committee, April 16, 2013.
[78] Defense Subcommittee, Senate Appropriations Committee, July 17, 2013.