Prompt Global Strike Weapons and Missile Defenses: Implications for Reductions in Nuclear Weapons

George Lewis

Introduction

If the United States and Russia seek to continue negotiated reductions in their nuclear arsenals, they will have to take into account the implications of technological advances for the stability, survivability, and effectiveness of such smaller nuclear forces. Such technological developments include long-range precision-guided conventionally-armed strike weapons; improved and expanded ballistic missile defenses; new intelligence, surveillance, and reconnaissance capabilities; deployment of anti-satellite or outer space weapons; laser weapons; cyber attacks; unpiloted and autonomous weapons, etc.; as well as developments that cannot yet be anticipated. While some possible technological developments may actually be able to assist future nuclear arms reductions (for example, by enhancing verification capabilities), most of them seem more likely to pose problems for such reductions by challenging long-standing assumptions about the survivability, stability, and effectiveness of existing and near-term offensive nuclear forces.

This paper focuses on two categories of emerging weapons technologies: Conventional Prompt Global Strike (CPGS) weapons and strategic-capable ballistic missile defense (BMD) systems. These two examples were chosen for several reasons. First, development of weapons in both categories is far enough along that it is possible to make near-to-medium term projections of what capabilities they might be able to provide. Second, both categories of weapons could potentially affect core elements of future nuclear arsenals, and significant concerns about their implications are already being raised. Third, large-scale deployments of these weapons have not yet occurred, leaving open the possibility that steps could still be taken to reduce their adverse implications for future nuclear reductions. Finally, they provide an interesting contrast in that CPGS weapons are offensive weapons, while BMD systems are intended for defensive purposes.

This paper will focus primarily on CPGS weapons and BMD systems in the context of the U.S.-Russian strategic nuclear forces and nuclear reduction efforts, with a secondary focus on their implications for China's nuclear forces. Some progress in further reducing U.S. and Russian nuclear forces appears to be possible in the face of CPGS weapons deployments. On the other hand, it is argued here that future deployments of BMD systems are likely to bring the U.S.-Russia nuclear reductions process to a standstill at levels above that at which other countries would become involved in reducing their own nuclear forces. A key factor in reaching this conclusion is the soon-to-begin large-scale deployments of strategic-capable naval interceptors. While planned or potential deployments of BMD systems are not motivated by U.S. concerns about Russian strategic nuclear forces, they are likely to be viewed by Russia as a severe threat to their nuclear missile force if it is reduced significantly below its current level.

Conventional Prompt Global Strike weapons

Conventional Prompt Global Strike (CPGS) weapons are long-range, high-speed, conventionally-armed weapons capable of striking within a short period of time, typically taken to be one hour.[1] Because they

[1] Recommended resources on CPGS weapons include: Amy F. Woolf, *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues*, Congressional Research Service Report R41464, October 2, 2015 (updated periodically), available at: https://www.fas.org/sgp/crs/nuke/R41464.pdf; James M. Acton, "Hypersonic Boost-Glide Weapons," *Science and Global Security*, Vol. 23, No. 3 (2015), pp. 191-219, available at:

are conventionally-armed, they must be highly accurate (a few meters) if they are to be able to destroy hardened targets. Thus they must have guidance and maneuver capabilities as they approach their targets. Although true intercontinental range is not required if they are able to be forward-deployed, they typically have long ranges (1,000 km or more), and their combination of speed and long range distinguishes them from existing precision-guided weapons. Despite long-standing interest in them, no CPGS weapons have been deployed yet (except for subsonic cruise missiles, which are also considered in this paper). This paper also simply assumes that CPGS weapons can be made to be reliable and accurate enough to merit actual deployment, which is not yet fully established for all the types of CPGS weapons discussed here.

What are CPGS weapons for?

The United States already has considerable capabilities to accurately strike targets around the world with conventionally-armed missiles such as the U.S. Navy's Tomahawk sea-launched cruise missile (SLCM) and the more recent air-delivered extended-range Joint Air-to-Surface Strike Missile. However, these missiles can take two to four hours to reach their targets and not all targets may be within their range.

CPGS weapons are intended to reduce this strike time to under an hour. At a minimum, they would be intended for striking small sets of high-value, time-urgent targets. In the U.S. context, examples of such targets include a meeting of the leadership of a terrorist group, an anti-satellite weapon that was being prepared for use against U.S. satellites, a rogue nation threatening or preparing to use a nuclear weapon, or a package of weapons of mass destruction or special nuclear materials temporarily located within a neutral country.[2] If plans to use CPGS weapons were restricted only to such targets, then only a small number of them might be needed. In addition to the weapons themselves, some types of CPGS attacks might also require faster and more sophisticated intelligence gathering, assessment and attack planning capabilities than are currently available.

The high speed, and in some cases maneuverability, of some types of CPGS weapons might enable them to successfully attack heavily defended targets, including the defenses themselves. For example, U.S. CPGS weapons might be used to attack elements of an adversary's anti-access and area denial system,

---

http://www.tandfonline.com/doi/pdf/10.1080/08929882.2015.1087242. (See also: James M. Acton, "Supplement to Hypersonic Boost-Glide Weapons," available at: http://www.tandfonline.com/doi/suppl/10.1080/08929882.2015.1087242/suppl_file/gsgs_a_1087242_sm8006.pdf, and David C. Wright, "Research Note to Hypersonic Boost-Glide Weapons by James M. Acton: Analysis of the Boost Phase of the HTV-2 Hypersonic Glider Tests," *Science & Global Security*, Vol. 3, No. 3 (2015), pp. 220-229); James M. Acton, *Silver Bullet?: Asking the Right Questions About Conventional Prompt Global Strike* (Washington, D.C.: Carnegie Endowment for International Peace, 2013), available at: http://carnegieendowment.org/files/cpgs.pdf; Dennis M. Gormley, *The Path to Deep Nuclear Reductions: Dealing with American Conventional Superiority*, Proliferation Papers #29, IFRI Security Studies Center, Fall 2009, available at: http://cns.miis.edu/other/PP29_Gormley.pdf; U.S. Department of Defense, Office of the under Secretary of Defense for Acquisition, Technology and Logistics, *Time Critical Conventional Strike from Strategic Standoff*, Report of the Defense Science Board, March 2009, available at: http://www.acq.osd.mil/dsb/reports/ADA498403.pdf; and Committee on Conventional Prompt Global Strike Capability, National Research Council, U.S. National Academies, *U.S. Conventional Prompt Global Strike: Issues for 2008 and Beyond*, 2008, available at: http://www.nap.edu/download.php?record_id=12061.

[2] These scenarios were put forth in NRC (2008), pp. 31-33 and summarized by Woolf (2015), p. 5.

such as radars and missile launchers, clearing the way for shorter-range and slower systems to more comprehensively attack the adversary. Such a role might require a much larger force of CPGS weapons than the attacks against "niche" targets mentioned in the preceding paragraph.

CPGS weapons could potentially destroy some targets that are currently vulnerable only to nuclear weapons. They could thereby reduce U.S. reliance on nuclear weapons, and in certain circumstances could eliminate the need to use a nuclear weapon. CPGS weapons could also give the U.S. President new attack options that would not be credible if carried out by nuclear weapons. Some advocates of CPGS weapons argue that they could directly substitute for some of the nuclear weapons in U.S. nuclear war plans, thus removing the need for some nuclear weapons and facilitating further nuclear reductions.[3]

In the United States, future prompt global strike weapons are viewed almost exclusively as conventionally-armed weapons, since existing intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles (SLBMs) already provide nuclear prompt global strike capabilities. While Russia and China may have similar interests in CPGS weapons, they are also believed to be interested in nuclear-armed prompt global strike weapons, in particular to defeat U.S. ballistic missile defense (BMD) systems.

Types of CPGS weapons

Three types of CPGS weapons, differing significantly in how they operate, have been the focus of programs in the United States and other countries: long-range conventionally-armed ballistic missiles, hypersonic boost-glide missiles, and hypersonic cruise missiles. Subsonic cruise missiles are also discussed here, because the possibility of using them in a zero-warning attack has led some in Russia to argue that they pose a threat comparable to CPGS weapons. A comparison of typical trajectories of the different types of CPGS weapons is shown in Figure 1.

[3] The most commonly cited figure is that highly-accurate conventional weapons could eliminate the need to use nuclear weapons on ten to thirty percent of the targets in the United States' Single Integrated Operational Plan (SIOP) nuclear war plan (as of 2005), according to an unnamed "industry official." Elaine M. Grossman, "U.S. General: Precise Long-Range Missiles May Enable Big Nuclear Cuts," *Inside the Pentagon*, April 28, 2005.

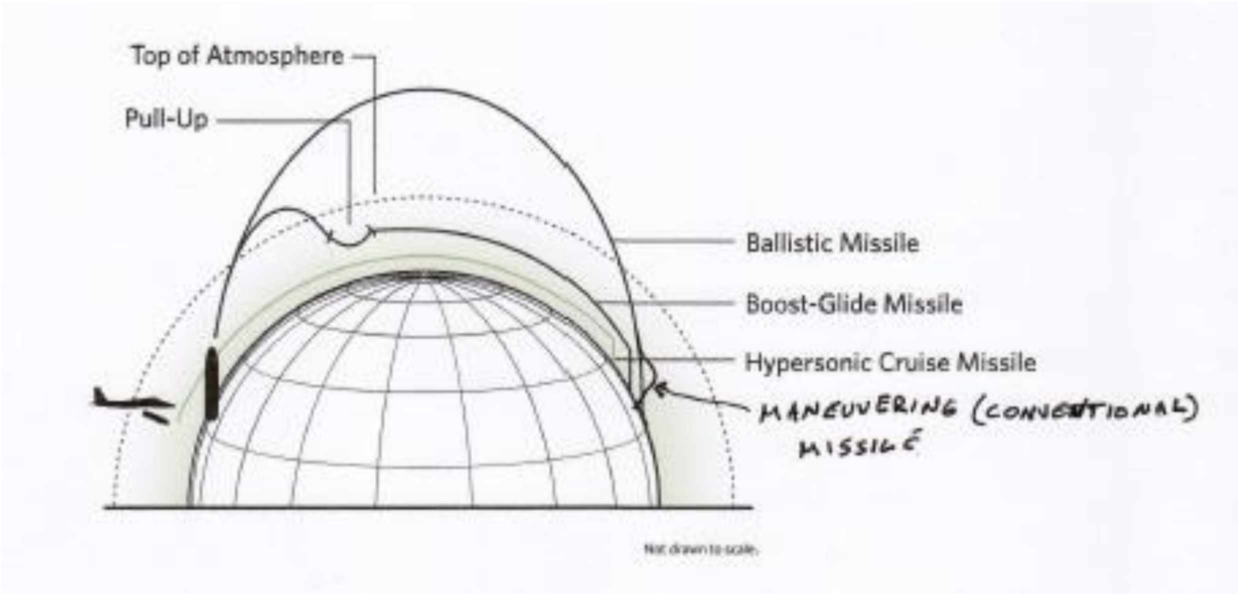

Figure 1. Comparative Trajectories of CPGS Weapons (altitudes not to scale). Adapted from Acton, *Silver Bullet?* Figure 1 (p. 7). A subsonic cruise missile would fly a trajectory similar to that of a hypersonic cruise missile, although typically at much lower altitudes.

Conventionally-armed long-range ballistic missiles

Conventionally-armed ballistic missiles are similar to long-range nuclear-armed ballistic missiles, but with the addition of a terminal maneuvering capability to provide the increased accuracy (3 to 10 meters or less) needed with a conventional warhead. Like the nuclear-armed missiles, they could be deployed either on land or at sea. The United States has been intermittently carrying out research and development on terminally-guided ballistic missiles for at least the last fifty years, initially with the objective of improving the accuracy and defense-penetration capabilities of nuclear-armed missiles. During the 1980s, the United States deployed in Europe just over 100 nuclear-armed Pershing II missiles which used a radar mapping system for terminal homing, giving an accuracy of about 50 meters. However, these missiles were eliminated under the terms of the 1987 Intermediate-range Nuclear Forces (INF) Treaty.

The U.S. Navy has conducted three flight tests (in 2002, 2005, and 2009) of a Trident II submarine-launched ballistic missile (SLBM) equipped with a terminal-maneuvering warhead, and in 2006 it proposed deploying a Conventional Trident Modification (CTM) system. Under the CTM plan two of the 24 Trident missiles on each of the twelve deployable Trident ballistic missile submarines would be converted to carry four conventionally-armed terminally-maneuvering warheads. However, this plan was not funded by Congress, which was particularly concerned about the possibility of a conventional attack being mistaken as a nuclear one.

The United States does not currently appear to have a program aimed at deploying a long-range conventionally-armed ballistic missile. Although the Department of Defense and the U.S. Navy now appear to be interested in the potential deployment of a submarine-launched intermediate-range conventional missile, as discussed in the next section this new missile will likely be a boost-glide weapon.

Hypersonic boost-glide weapons

Hypersonic boost-glide vehicles are launched by a rocket booster onto a ballistic trajectory that reenters the atmosphere far from its intended target.[4] Upon reentering the upper part of the atmosphere the glide vehicle transitions into a high-speed glide that can extend for thousands of kilometers. During this gliding portion of its flight, the vehicle can carry out extensive maneuvers, potentially varying its impact point by thousands of kilometers. As it nears its target, it goes into a steep dive to accurately strike its target.

While the maneuvers of a conventional maneuvering ballistic missile are also carried out using aerodynamic lift (that is, by gliding), the ballistic missile differs from a boost-glide weapon because it maneuvers only in the terminal phase of its flight as it approaches its target. In contrast, a boost-glide weapon will use aerodynamic lift over much or even most of its flight.[5] As long as the majority of its trajectory is in non-ballistic gliding flight, a boost-glide weapon is not limited by the New START Treaty.

Two U. S. programs, one cancelled and one ongoing, illustrate the possible nature of a future hypersonic boost-glide weapon. The very ambitious Hypersonic Test Vehicle-2 (HTV-2) program was intended to achieve a 17,000 km range, with a cross-range capability of 6,000 km and with a peak gliding speed of Mach 20 (21,000 km/h = 13,000 mph).[6] Launched on a modified MX ICBM booster, this range and speed combination would have allowed the wedge-shaped HTV-2 glide vehicle to strike anywhere on earth within an hour from launch sites in the continental United States. However, in two test flights in 2010 and 2011, the HTV-2 glide vehicle failed shortly after leaving the ballistic portion of its trajectory, and the program has been effectively cancelled.

The Advanced Hypersonic Weapon (AHW) is a less ambitious program, with a shorter range, likely 6,000 to 8,000 km, a correspondingly lower glide speed (perhaps about Mach 12), and an accuracy goal of 10 meters. The AHW's glide vehicle uses a conical design that had previously been flight-tested several times as a ballistic missile warhead. Given its shorter range, the AHW would likely be deployed at sea or at forward operating bases. In 2012, a successful test of the AHW was conducted in which it flew about 4,800 km in less than a half hour. A second, longer-range, test in 2014 failed for a reason unrelated to the AHW itself. Although the AHW was originally developed by the Army, the program has recently been turned over to the Navy, which is developing a version that can be launched from submarine missile launch tubes. The first flight test of this naval version of the AHW is planned for 2018 using a land-based launcher, with a second test to follow by about 2020.

---

[4] The term "hypersonic" refers to speeds greater than five times the speed of sound. The speed of sound is 340 m/s at sea level, so at sea level hypersonic means a speed greater than 1.7 km/s = 3,800 mph.

[5] As noted by Acton (2013), p. 37, ballistic missiles and boost-glide weapons lie on opposite ends of a continuum regarding the fraction of their trajectory that is non-ballistic. An important point on this continuum is where the fraction of the missile's trajectory that is non-ballistic is greater than half, because that condition exempts the missile from some arms control limitations.

[6] The speed of sound between altitudes of 50 and 100 km varies from about 330 to 275 m/s.

The Air Force is also developing a Tactical Boost Glide (TBG) system. The TBG system would use a rocket booster to accelerate a glider vehicle to a speed of greater than Mach 9. Current plans call for this system, with a range of "several hundred miles" to be first flight tested in 2019.[7]

Hypersonic cruise missiles

A hypersonic cruise missile uses a supersonic combustion ramjet (scramjet) engine to achieve hypersonic speeds while travelling through the upper atmosphere. A scramjet omits the compressor fans used in a conventional jet engine to create high air pressure in its combustion chamber, instead using the high speed of the air entering its inlet to achieve the necessary compression. Initiating engine combustion requires boosting the missile to a speed of about Mach 4 or higher, which typically is achieved using a rocket booster stage. Hypersonic cruise missiles would most likely be deployed on bomber aircraft.[8] Although recent and planned hypersonic cruise missiles have ranges of less than 1,000 km, they are discussed here because they are frequently categorized as CPGS weapons.

The United States has recently completed a series of flight tests of a hypersonic cruise missile known as the X-51A Waverider. After three partially successful tests in 2010, 2011, and 2012, an X-51A completed a fully successful test in May 2013. A brief description of this final test illustrates the basic operation of this type of missile.[9] The Waverider was launched from a B-52 bomber at an altitude of about 50,000 feet and at a speed of about Mach 0.8. A rocket booster stage then burned for 29 seconds, accelerating the Waverider to a speed of Mach 4.9 at an altitude of 63,000 feet. The missile's scramjet motor then took over and burned for over 200 seconds, boosting the Waverider to a speed of Mach 5.1 at an altitude of 64,000 feet before running out of fuel. The Waverider then glided to a controlled impact. The total flight lasted about six minutes and covered about 430 km.

The successor to the Waverider program is the joint DARPA/Air Force Hypersonic Advanced Weapons Capability (HAWC) which is intended to demonstrate by 2019 a capability to fly 500 miles at Mach 6 and strike a target.[10] If its program of testing is successful, the Department of Defense "will be ready for a program of record in an air breathing Scramjet hypersonic weapon."[11] One of the objectives of this program is developing and testing a more weaponized missile than the Waverider.[12]

---

[7] Statement Testimony of Allen Schaffer, Subcommittee on Emerging Threats and Capabilities, House Armed Services Committee, March 26, 2015, p. 18. Available at: http://docs.house.gov/meetings/AS/AS26/20150326/103242/HMTG-114-AS26-Wstate-ShafferA-20150326.pdf.

[8] U.S. and Russian ground-launched cruise missiles missile with ranges between 500 and 5,500 km are prohibited by the INF Treaty. Scramjets use liquid fuel, which for safety reasons is prohibited on missiles deployed on U.S. Navy ships and submarines,

[9] This description is based on Guy Norris, "High-Speed Strike Weapon to Build on X-51 Flight," *Aviation Week and Space Technology*, May 20, 2013.

[10] Testimony of Allen Schaffer, p. 18.

[11] Ibid.

[12] The Waverider was too heavy to be effectively delivered by current U.S. bombers (the B-52 used to launch it in tests carried very little fuel in order to achieve the desired launch conditions), had no warhead, and did not have a terminal seeker, which is desired for the HAWC.

Subsonic long-range cruise missiles

The U.S. already possesses several types of long-range cruise missiles, both conventional and nuclear-armed. U.S B-52H bombers are each capable of carrying up to twenty AGM-86B nuclear air-launched cruise missiles (ALCMs). The AGM-86 is officially described as having a range of 1,500+ miles (2,400+ km).[13] Under New Start, the United States plans to retain about 42 B-52Hs as nuclear-capable bombers. While these bombers could theoretically carry over 800 nuclear ALCMs, only about 575 remain in the U.S. inventory.[14]

The U.S. plans to begin replacing the AGM-86B ALCM with a new nuclear-armed Long-Range Standoff (LRSO) weapon. The LRSO will have a range similar to or greater than the existing ALCM but will be stealthier. The Air Force plans to buy a total of about 1,000 LRSOs, with first deliveries beginning in 2026.[15] The purchase of a total of 1,000 LRSOs would likely support an operational force of about 500-600 weapons (which would seem to indicate that the Air Force does not expect to see any significant reduction in the number of its bomber-delivered nuclear weapons). These weapons would be deployed on the B-2, the B-52H, and eventually on the new Long-Range Strike Bomber.

Between 1986 and 2001, the Air Force converted several hundred AGM-86Bs into conventionally-armed ALCMs (CALCMs). These were designated the AGM-86C (unitary warhead) and the AGM-86D (submunition warhead). These missiles have about half the range of the nuclear-armed ALCMs and have been used in combat on several occasions. Although some CALCMs remain in inventory, the Air Force plans to retire them in favor of the new extended-range Joint Air to Surface Standoff Missile (JASSM-ER), which began deployment in 2014.[16] The JASSM-ER, which does not have a nuclear-armed variant, has a range of about 900 km. It is equipped with a data link for inflight updates and an infrared seeker for terminal homing. The JASSM-ER will initially be deployed on B-1B bombers, but will eventually be deployable on all types of heavy bombers and many types of shorter-range attack aircraft.

The Tomahawk land-attack missile (TLAM) is currently deployed on U.S. Navy attack submarines, cruisers, and destroyers. In addition, four Trident submarines have been modified to be able to carry seven Tomahawks in 22 of their 24 former Trident II SLBM launch tubes, giving a total of 154 Tomahawks per submarine (which are now designated as SSGNs).[17] A nuclear-armed version of the Tomahawk was withdrawn from service and placed in storage as a result of the 1991 Presidential unilateral initiatives, and has subsequently been eliminated.

The most recent version of the Tomahawk is the Block IV TLAM-E, also known as the Tactical Tomahawk. TLAMs navigate with a combined inertial plus GPS guidance system, supplemented by a mid-flight radar terrain contour-matching system and a terminal visual digital scene-matching system, providing an accuracy likely in the range of three to ten meters. The Tactical Tomahawk adds a two-way satellite data link that enables the missile to be re-programmed during flight to a new target, to provide battle-damage assessment data (on earlier strikes), and to be able to loiter in the vicinity of suspected targets. The official range for the Tactical Tomahawk is 1,600 km, although it actually may be greater than this.

---

[13] U.S. Air Force, "Factsheet: AGM-86B/C/D Missiles." Available at: http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104612/agm-86bcd-missiles.aspx.

[14] Kingston Reif, "Air Force Wants 1,000 New Cruise Missiles," *Arms Control Today*, May 7, 2015. Available at: https://www.armscontrol.org/ACT/2015_05/News/Air-Force-Wants-Thousand-New-Cruise-Missiles.

[15] Reif, "Air Force Wants."

[16] "Joint" refers to the original plan under which both the U.S. Air Force and the U.S. Navy would use the weapon. However, the Navy subsequently pulled out of the program.

[17] "SS" stands for submarine, "G" for guided missile, and "N" for nuclear-powered.

Over 3,000 Tactical Tomahawks have been delivered to the U.S Navy so far. The Navy plans to add a number of improvements to the Tactical Tomahawks as they return for a 15 year recertification program starting in 2019. Possible improvements include a new Joint Multi-Effects Warhead System (JMEWS), which combines blast-fragmentation and penetration capabilities in a single warhead, improved communication capabilities, and a new seeker that could improve capabilities against moving targets.

Other countries

Russia has a long-standing interest in hypersonic boost-glide vehicles, and appears to have recently accelerated testing of one such system. Russia has apparently conducted four flight tests of its YU-71 hypersonic boost-glide vehicle since December 2011.[18] These test launches were conducted using SS-19 ICBM boosters, indicating that the YU-71 could have an intercontinental range. It is unclear if any of these tests have been successful; if, however, this technology is successfully developed, Russia could potentially deploy a small number of these boost-glide weapons, armed with either nuclear or conventional warheads, sometime in the 2020s.

The U.S. Department of Defense has stated that China is deploying "a growing number" of conventionally-armed medium-range ballistic missiles with maneuverable warheads, in particular the 1,500 km range DF-21D anti-ship ballistic missile.[19] The same report also stated that, "The United States and China acknowledge that the Chinese tested a hypersonic glide vehicle in 2014."[20] This glide vehicle is apparently the WU-14, which was flight tested three times in 2014, and most recently in June 2015. Few details about the WU-14 are available, although it is usually described as having a speed up to Mach 10, and the 2015 test reportedly involved extensive maneuvering.[21]

Russian and Chinese interest in hypersonic boost-glide weapons may be particularly motivated by their ability to evade above-the-atmosphere missile defense interceptors, such as the Ground-Based Interceptor (GBI) of the U.S. Ground-Based Midcourse Defense (GMD) national missile defense system or the several versions of the SM-3 interceptor used in the U.S. Navy's Aegis BMD systems. These interceptors can only operate at altitudes above about 100 km, while almost all of the glide portion of a boost-glide weapon's trajectory will take place at altitudes below 100 km, making intercepts by existing GBI or SM-3 interceptors essentially impossible.[22]

---

[18] Pavel Podvig and Alexander Stukalin, "Russia Tests Hypersonic Glide Vehicle, *Jane's Intelligence Review*, Vol. 27, No. 7 (July 2015).

[19] U. S. Department of Defense, "Military and Security Developments Involving the People's Republic of China 2015," Annual Report to Congress, 2015, p. 8. Available at: http://www.defense.gov/Portals/1/Documents/pubs/2015_China_Military_Power_Report.pdf.

[20] U. S. Department of Defense, "Military and Security Developments, p. 32.

[21] Bill Gertz, "China Conducts Fourth Test of WU-14 Strike Vehicle, *Washington Free Beacon*, June 11, 2015. Available at: http://freebeacon.com/national-security/china-conducts-fourth-test-of-wu-14-strike-vehicle/print/.

[22] For this reason, the Missile Defense Agency is reportedly interested in developing an extended-range version of the U.S Army's Terminal High Altitude Area Defense (THAAD) system, although no decision to do so has been made yet. (Amy Butler, "THAAD-ER in Search of a Mission," *Aviation Week and Space Technology*, January 20, 2015.) Even if a decision is made to develop a THAAD-ER system, which may be able to intercept down to altitudes of about 40 km, it may be difficult for it to intercept a highly maneuverable, intercontinental-range vehicle, and a large number of THAAD-ER systems might be needed to cover U.S. territory. In addition, the low-altitude and

Both Russia and China also possess long-range land-attack subsonic cruise missiles. Russia has long deployed the kH-55 nuclear air-launched cruise missile, with a range of 2,500-3,000 km, on bomber aircraft. A conventionally-armed version, the kH-555, presumably has a shorter range. Newer ALCMs, the nuclear kH-101 and the conventional kH-102, are now being deployed. In late 2015, Russia launched conventionally-armed Kalibr cruise missiles, with a range greater than 1,500 km, from both ships and submarines against targets in Syria. Less information is available about Chinese missiles, but their CJ-10 (sometimes DH-10) cruise missile reportedly comes in both nuclear and conventional variants, and has a range of up to 1,500-2,000 km.

Concerns raised by CPGS weapons

In the United States at least, the most frequently cited concern about CPGS weapons is that a launch of a conventionally-armed ballistic missile against a third party might be wrongly interpreted by other countries as launch of a nuclear-armed missile, thereby inadvertently triggering a nuclear war. For example, an attack by the United States on North Korea using conventionally-armed ICBMs or SLBMs could be mistaken by Russia or China (if it develops a warning system capable of detecting such a launch) as the beginning of a nuclear attack against them. While there are steps that can be taken to reduce the likelihood of such a mistaken interpretation, this concern has played a prominent role in leading Congress to refuse funding for the deployment of conventionally-armed ICBMs or SLBMs.

Other types of CPGS weapons could also lead to confusion over what country they are being used against, again depending on the state of the attacked country's early warning system. For example, if Russian early warning satellites are able to detect the launch of SLBMs, they would also be able to detect the launch of hypersonic boost-glide vehicles from submarines. But whereas the SLBM's warheads impact points can be roughly estimated, even after the rocket motor has burned out, because they are on ballistic trajectories, the impact point for a boost-glide vehicle cannot be similarly estimated. Since the boost-glide vehicle can make quite large maneuvers, the early warning satellites may not even be able to tell which country is the aim point. Moreover, because most of the glide path takes place at relatively low altitudes (well below 100 km) the boost glide vehicle may also be able to maneuver to avoid detection by Russia's early warning radars.[23]

CPGS weapons could also blur the distinction between conventional and nuclear weapons in wars between countries possessing both CPGS weapons and nuclear weapons. For example, a Chinese attack on U.S. forces in Asia using conventionally-armed ballistic missiles could potentially be confused with the beginning of a nuclear attack. This is particularly the case if the missiles used have both conventional and nuclear variants, as the Chinese DF-15 does.

Some types of CPGS weapons may share some support facilities (command and control centers, radars and other sensors) with nuclear forces. In this case, the country being attacked may not know whether the attack is directed against its conventional forces or nuclear forces (or because of the damage inflicted on its nuclear forces, it may not care). Thus, use of CPGS weapons could inadvertently escalate a conventional war to a nuclear one. This situation could be worse if dual nuclear/conventional PGS weapons were involved.

---

unpowered nature of the glide portion of a boost-glide weapons trajectory could pose severe problems for the U.S. early warning and missile defense sensors.

[23] It is possible that as the glide vehicle heats due to atmospheric friction, it may once again become visible to early warning satellites. This is more likely to be the case for U.S. satellites than Russian ones.

These concerns may be reasons for proceeding carefully with the deployment of CPGS weapons, but they are not necessarily obstacles to further reductions in nuclear weapons.

The biggest problem posed by deployment of CPGS weapons for future nuclear weapons reductions is the concern is that they could be used in direct attacks on another country's nuclear forces. To the extent that a country feels that its nuclear forces may be threatened by another country's CPGS weapons, it may refuse to consider further reductions in its nuclear forces and/or place them on higher levels of alert in order to maintain a second strike capability.

If CPGS weapons were fitted with penetrating warheads and could achieve accuracies of about 3 meters or less, then they could potentially be used to attack hardened targets such as ICBM silos. Weapons such as subsonic cruise missiles that can receive in-flight guidance updates and can loiter in the suspected vicinity of targets potentially could be used to hunt down mobile missile launchers. Such CPGS weapons could be used either in conjunction with nuclear weapons or entirely separately in a conventional-only disarming first strike.

A variant of this disarming conventional attack which has been raised by Russian analysts is one in which subsonic cruise missiles are used to conduct a zero warning attack on Russian ICBMs, bombers, and in-port submarines.[24] In this scenario, U.S. submarines, which are at present essentially undetectable by Russia, would approach close in to the shores of Russia and neighboring countries, and launch Tomahawk cruise missiles in a coordinated attack. The Tomahawks, which are modestly stealthy, would fly low on paths, avoiding Russian air defenses, and arrive at their targets simultaneously.

Finally, CPGS weapons could pose additional verification problems for future nuclear reductions. At current levels of nuclear weapons this may not be a problem. For example, SLCMs are neither limited nor verified (since even if nuclear armed they are tactical, not strategic, weapons), and there does not seem to be much concern about counting or verifying them at the current level of strategic forces. At lower levels of strategic forces, however, there could be concerns that CPGS weapons were being covertly converted to carry nuclear warheads. On the other hand, including CPGS weapons in strategic nuclear arms agreements could significantly complicate the verification of such agreements. For some types of CPGS-like weapons it may even be difficult to reach agreement on whether or they should even be covered by nuclear arms agreements. As discussed below, Russian nuclear-armed boost-glide weapons are one potential source of disagreement. For the purposes of this paper, we will simply assume that means of verification could be found if it were deemed to be necessary.

CPGS weapons and arms control treaties

At present U.S. and Russian nuclear forces are primarily limited by two treaties: the 1987 INF Treaty and the 2010 New Start Treaty. The INF Treaty, which is of unlimited duration, bans the U.S. and Russia from possessing land-based ballistic and cruise missiles with ranges between 500 and 5,500 km, regardless of whether they are conventional or nuclear armed.

---

[24] Yevgeny Miasnikov, "Precision-Guided Conventional Weapons," in *Nuclear Reset: Arms Reductions and Nonproliferation*. Alexie Arbatov and Vladimir Dvorkin, eds. (Natalia Bubnova, English ed.), (Moscow: Carnegie Center Moscow, 2012), pp. 432-456. Available at: http://carnegie.ru/publications/?fa=49796.

The New START Treaty limits both ICBMs and SLBMs, and defines a ballistic missile as "a weapon-delivery vehicle that has a ballistic trajectory over most its flight path."[25] New START imposes several numerical limits on strategic nuclear forces, including a total of 1,550 on deployed ICBM warheads + deployed SLBM warheads + deployed heavy bombers equipped for nuclear armaments, and a total of 700 deployed ICBMs + deployed SLBMs + deployed heavy bombers equipped for nuclear armaments. The Treaty's limits enter into force in February 2018 and the Treaty expires in 2021.

The New START Treaty does not distinguish between nuclear- and conventionally-armed ICBMS and SLBMs. Thus any conventionally-armed ICBMs and SLBMs and their warheads are limited by New START and are counted under the same counting rules as nuclear-armed ICBMs and SLBMs.

U.S. and Russian ground-launched hypersonic boost-glide weapons (conventional or nuclear) with ranges between 500 and 5,500 kilometers are banned under the INF Treaty.[26] The United States has already stated that conventionally-armed boost-glide weapons are not limited by New Start because they fly on trajectories that are non-ballistic over most of their flight path and thus are not new kinds of strategic offensive arms subject to consultation under the Treaty.[27] Although Russia has the right under the Treaty to challenge that interpretation by claiming that long-range boost-glide weapons are a "new kind of strategic offensive arm," U.S. government officials have expressed confidence that such a challenge would not interfere with their deployment.[28]

As noted above, Russia may be interested in deploying intercontinental nuclear-armed boost-glide weapons. While these might seem to clearly be a new kind of strategic offensive force, the New START Treaty does not distinguish between nuclear and conventionally armed ICBMs and SLBMs – both are limited because of the difficulty of verification. Thus Russia might argue that if conventionally-armed boost-glide weapons are excluded from the Treaty's limits because they do not have primarily ballistic trajectories, so nuclear boost-glide weapons should also be excluded.

Finally, all ground-launched hypersonic cruise missiles with a range of between 500 and 5,500 km would be prohibited by the INF Treaty. Heavy bombers equipped with nuclear air-launched hypersonic cruise missiles would be subject to New Start counting rules. There are no arms control limits on sea-launched hypersonic cruise missiles.

CPGS weapons at the New START level

With the exception of subsonic cruise missiles, any CPGS weapon deployments are likely to be quite limited by the time the New Start Treaty expires in February 2021. However, it could be advantageous to both the United States and Russia to extend this Treaty (possibly with some modifications and clarifications). This section focuses on the question of whether or not potential deployments of CPGS

---

[25] New Start Protocol, p. 2. Available at: http://www.state.gov/documents/organization/140047.pdf.

[26] These weapons appear to fall under the Treaty's definition of a cruise missile, which is "…an unmanned, self-propelled vehicle that sustains flight through the use of aerodynamic lift over most of its flight path." Some have argued that boost-glide weapons are not self-propelled (the gliding vehicle itself does not contain any propulsion) and thus they are not covered by the INF Treaty (see, for example, http://www.nipp.org/wp-content/uploads/2014/12/CPGS-REPORT.pdf, p. 32). However, Woolf, "Conventional Prompt Global Strike," pp. 38-39, says they are banned by the INF Treaty.

[27] Woolf, "Conventional Prompt Global Strike, pp. 39-40.

[28] Ibid.

weapons could interfere with an extension of New START. More specifically, it asks if U.S. deployments of CPGS will threaten Russia's confidence in the assured retaliatory capability of its strategic nuclear forces.

Table 1 below shows an estimated composition of the U.S. and Russian strategic forces shortly after the New START limits go into effect in 2018.

	United States (deployed)		Russia (deployed)	
	Delivery Systems	Warheads	Delivery Systems	Warheads
ICBMs	400	400	~280	~814
SLBMs	240	Up to 1,090	~144	~676
Bombers	60	60 (accountable) Up to 288 (bombs) Up to 575 (ALCMs)*	~60 (accountable)	~60 (accountable) ~750
Not limited Non-Strategic Weapons		*~ 200 bombs*		*~2,000 of multiple types*

*The 288 bombs estimate is based on 18 B-2 bombers x 16 bombs. The 575 ALCMs is approximately the number remaining in the U.S. inventory.

Table 1. Approximate U.S. and Russian Forces under New START (2018)[29]

Kristensen and Norris make several relevant points regarding the Russian forces in the mid 2020s, assuming New START is extended.[30] First, the fraction of the Russian ICBM warheads on mobile systems will increase from its current 32% to 66% by 2024. Second, the fraction of the ICBMs that are MIRVed will increase from the current 43% to 73% by 2024.[31] Third, the fraction of the ICBM warheads that will be MIRVs will be about 90%. The MIRVing of the SLBM force will also increase as new six-warhead SS-N-32s replace older SS-N-18s (two warheads) and SS-N-23s (four warheads).

How would U.S. deployments of CPGS weapons affect the survivability Russia's strategic nuclear forces?

Currently, Russian strategic nuclear forces are survivable only to the extent that they either cannot be targeted – mobile ICBMS in the field, SLBMs on patrols, possibly dispersed bombers – or can be launched on warning of an attack. The nearly 1,500 ballistic missile warheads the United States will

---

[29] U.S. forces based on U.S. Department of Defense, "Fact Sheet on U.S. Nuclear Force Structure under the New START Treaty," (no date). Available at: http://archive.defense.gov/documents/Fact-Sheet-on-US-Nuclear-Force-Structure-under-the-New-START-Treaty.pdf. Russian forces estimated based on Hans M. Kristensen and Robert S. Norris. "Nuclear Notebook: Russian Nuclear Forces," *Bulletin of the Atomic Scientists*, May/June, 2015. Available at: http://bos.sagepub.com/content/71/3/84.full.pdf+html. Specifically, to get the SLBM numbers, two Delta III submarines are assumed to be retired and one additional Borey submarine to be deployed. The numbers of ICBM warheads is then adjusted downwards to bring the total number of accountable warheads to 1,550. Russian ICBM numbers from chart in Hans M. Kristensen, "New Nuclear Notebook: Russian Forces" available at: https://fas.org/blogs/security/2015/04/russianotebook/.

[30] Kristensen and Norris, "Nuclear Notebook: Russian Nuclear Forces 2015."

[31] MIRV stands for Multiple Independently-Targeted Warheads. A MIRved missile carries several warheads, each of which can be guided to a different target.

retain under New Start are more than enough to destroy all Russian strategic nuclear forces several times over if those forces could be targeted. Thus unless a U.S. CPGS system either provides some way to find mobile targets which is not available for use with ICBMs or SLBMs or can attack with shorter warning times than the 15-20 minutes associated with a U.S. SLBM attack, they will not substantially increase the vulnerability of the Russian strategic forces to a disarming first strike.[32]

First, conventionally-armed ICBMs and SLBMs are not an issue, since they would be counted under New START as if they are nuclear armed. Deploying any conventionally-armed ICBM or SLBM warheads would require elimination of an equal number of nuclear warheads.

Conventionally-armed hypersonic cruise missiles are unlikely to be a serious problem either. At least initially, their ranges will be much too short to threaten Russian ICBMs or heavy bomber bases.[33] If hypersonic cruise missiles were ever to achieve the ranges necessary (~2,500 km) to attack all of these targets, their flight times would be roughly 20 minutes, comparable to that of existing SLBMs. Unlike subsonic cruise missiles, hypersonic ones could not attempt a zero-warning attack because, even if their booster rocket is not detected, they fly high enough (above 50,000 feet) to be detected by air defense radars at ranges of roughly 500 kilometers or more.

Hypersonic boost-glide weapons will likely have flight times comparable to ICBMs and SLBMs of similar ranges. (Although the boost-glide weapons fly a shorter total distance because they fly lower, their speed will decrease significantly towards the end of their gliding flight.) Although they may be difficult for an early warning system to track after their booster rockets burn out, the launch of enough hypersonic boost-glide weapons to threaten a significant fraction of Russian silo-based ICBMs and mobile missile garrisons would be an unmistakable event (except for possibly confusing it with the launch of a similar number of ICBMs or SLBMs), which would certainly seem to run a risk of a Russian launch on warning (which illustrates why the deployment of these weapons is potentially dangerous).

A final possibility is that of a zero-warning attack using subsonic cruise missiles such as Tomahawks. Such an attack would require a significant number of such missiles, perhaps as many as 600 or more, assuming that two-on-one targeting is required to get reliabilities above 90%. In addition, the kill probability of conventionally-armed cruise missiles is likely to be significantly lower than of a weapon with a nuclear warhead. Even if an accuracy of three meters is achieved, that still means that half of the missiles will fall more than three meters away. Although the submarines that might be used to launch such an attack may be essentially undetectable, the launch itself, involving hundreds of rocket booster motors igniting in or just above the water, is another matter. Moreover, it is far from clear that that the Tomahawk even has the range necessary for such an attack.[34]

---

[32] Since CPGS weapons cannot be used against submarines at sea, we will restrict the discussion here to their use against ICBMs.

[33] Recall that the current U.S. demonstration program is aiming for a missile with a range of about 500 miles (about 800 km).

[34] Such an attack would require a minimum Tomahawk range of about 2,500 km, assuming submarines very close to shore. Figure 1 of Gormley is a map showing that a Tomahawk range of 2,500 km is not enough to cover all ICBMs, assuming launch points 200 nautical miles (370 km) offshore. (Gormley, "The Path to Deep Nuclear Reductions," p. 44.) In contrast, Miasnikov argues that if the some of the launching submarines are much closer to shore than 200 nautical miles, all of the ICBM's deployment areas can be covered. (Miasnikov, "Precision-Guided Conventional Weapons," pp. 444-448.)

The official range for the current Tactical Tomahawk is 1,600 km. This is likely an operational range, which includes allowances for low altitude and non-straight-line flight, so the maximum range would be higher. A 1992 calculation

Leaving these factors aside, the feasibility of such a zero warning attack hinges on the idea that, because they have on-board imaging sensors and the ability to loiter over the target area and exchange data with remote command centers, the Tomahawks will be able to search for and locate Russian mobile missile launchers. As Gormley points out, not only will such Tomahawks have little fuel remaining for loitering, but finding a few hundred launchers camouflaged and hidden by Russian forces with four decades of experience with mobile missile operations seems implausible.[35] A Tomahawk that climbed high enough to even be able to attempt to search could expose itself to Russian air defenses, which would likely have little trouble shooting it down.

Moreover, this is not a threat which will increase significantly in the future, unless there is a breakthrough in tracking mobile missiles (from space, for example). As noted above, the United States already has more than 3,000 of the latest version of the Tomahawk.

Reductions below New START

If, as argued above, the retaliatory capability of Russia's strategic nuclear forces is not threatened by CPGS weapons at New START force levels, then based solely on the survivability of these nuclear forces, reductions to levels much lower than that of New START should be feasible. Specifically, Russia could greatly reduce its number of ballistic missile warheads without significantly increasing the vulnerability of its nuclear forces. This is because significant reductions in total strategic warhead numbers could be accomplished almost exclusively by de-MIRVing. As noted above, by the mid-2020s, 90% of the Russian ICBM force and all of its SLBMs will be MIRVed. In this situation, the number of warheads could be significantly reduced – by a factor of two or possibly even three – without reducing the number of ICBMs, SLBMS, and bombers at all.[36] Similar reductions could be made to U.S. forces, although some ICBMs might need to be eliminated because of their greater number (400) relative to U.S. SLBMS. The overall survivability of the Russian strategic nuclear forces could actually be enhanced somewhat because there would be significantly fewer U.S. warheads available to attack them. In addition, such a de-MIRVing could significantly reduce the first-strike instability inherent in a highly-MIRVed Russian ICBM force facing a larger (in terms of number of missiles) force of single-warhead U.S. ICBMs.

Unfortunately, reductions well below New START will not be based solely on considerations of the survivability of nuclear forces. As discussed below, ballistic missile defenses are likely to pose a much more significant obstacle to deep nuclear reductions. At levels well below New START, the nuclear forces of other countries also will have to be taken into account, which will greatly complicate further reductions.

The overall state of U.S.-Russia relations may be much more important than the details of numbers and capabilities of CPGS weapons. The simple existence of large numbers of U.S. CPGS weapons may

---

estimated that the nuclear version of the Tomahawk (which has since been retired), which had a lighter warhead and carried more fuel, had a sea-level, straight-line range of about 3,400 km. (George N. Lewis and Theodore A. Postol, "Long-Range Nuclear Cruise Missiles and Stability," *Science and Global Security* Vol. 3, No. 1-2 (1992), pp. 49-99, available at: http://scienceandglobalsecurity.org/archive/sgs03lewis.pdf). The conventional Tomahawk was typically described as having a range of about half of that of the nuclear one, so even with some subsequent range improvements, the current Tomahawk may fall short of a range of 2,500 km.

[35] Gormley, "The Path to Deep Nuclear Reductions," pp. 35-37.

[36] Some method of limiting the number of weapons for nuclear heavy bombers would also have to be agreed to.

contribute to the overall sense of threat felt by Russian leaders, and thus also to a reluctance to further reduce their nuclear forces. Regardless of their actual capabilities, it may be no easier to convince Russian decision makers that U.S. CPGS weapons are not a threat to the their nuclear forces than it is to convince them their nuclear forces could defeat U.S. ballistic missile defenses. In addition, at low levels of nuclear forces, large numbers of CPGS weapons could raise breakout issues, because they could also be armed with nuclear weapons.

It could be both feasible and desirable to restrain the numbers of some types of CPGS weapons, particularly those that combine the highest speeds with the longest ranges, such as conventionally-armed ICBMs and SLBMs or intercontinental-range boost-glide weapons. As noted above, if they are needed at all, the number of CPGS weapons needed to counter niche threats such as a meeting of terrorist leaders is likely to be quite small. The cancelled U.S. Conventional Trident Modification program envisioned only 24 such missiles, with a total of 96 warheads, only a third of which would be on station in normal circumstances. The U.S. has stated that that should it decide to deploy conventionally-armed ICBMs or SLBMs, counting their warheads against the New START limits would not prevent the United States from “maintaining a robust nuclear deterrent.”[37] Taken together with possible Russian interest in nuclear-armed intercontinental-range boost-glide weapons to defeat U.S. national missile defenses, this suggests that the warheads of any intercontinental-range CPGS weapons could be counted against the limit on warheads of nuclear ICBMs or SLBMs in at least the next U.S.-Russia nuclear arms reduction agreement, if there is one.

However, shorter-range CPGS weapons may actually pose a greater threat to nuclear reductions beyond New START. The United States’ most significant CPGS program at present appears to be aimed at the development of a conventionally-armed hypersonic boost-glide weapon for future deployment on U.S. Navy submarines and possibly surface ships. Although this weapon is based on the AHW glide vehicle, which was intended to demonstrate a range of 6,000-8,000 km, the range of a deployed weapon could be less than that due to constraints imposed by launcher tube sizes on submarines or ships. Nevertheless, it would likely have enough range to strike anywhere within Russia or China from forward-deployed submarines or ships. Such a missile is not subject to any existing arms control limit, and depending on the missions it is intended for, it might be deployed in large enough numbers to preclude counting them against a limit on nuclear warheads in a future treaty. If the United States was willing to accept any limits on such weapons, it would be possible to limit them separately, although there could be some difficulties involved in verifying their numbers and non-nuclear status, unless they are deployed on SSBNs or SSGNs.[38] Despite the fact that such weapons could not destroy survivably-based Russian nuclear forces, an unlimited and unverified deployment of them would certainly raise concerns in Russia and could increase its reluctance to agree to further nuclear reductions.

CPGS weapons summary

The United States has been intermittently developing three different types of CPGS weapons – hypersonic cruise missiles, conventionally-armed ballistic missiles, and hypersonic boost glide weapons – over the last several decades, and could potentially deploy one or more of these weapons in the 2020s.

[37] Secretary Gates to U.S. Senate Foreign Relations Committee, October 1, 2010, quoted in Woolf, “Conventional Prompt Global Strike,” p. 40.
[38] In particular, Acton, “Silver Bullet,” p. 139 argues the U.S. Navy would be very reluctant to accept inspections of its attack submarines.

Hypersonic cruise missiles do not appear to pose a major obstacle to future reductions in strategic nuclear forces because they are unlikely to have enough range to threaten targets deep in the interior of a large country like Russia. They are also likely to be readily detectable and possibly interceptable because they cannot fly low enough to avoid detection by air defense systems' radars.

The United States does not currently appear to have a program aimed at developing and deploying a long-range conventionally-armed ballistic missile. Congress has refused to provide funding for such a weapon, primarily because of concerns that the launch of such a missile might be mistaken for the launch of a nuclear-armed missile. However, a conventionally-armed ballistic missile could be a fallback approach if the development and deployment of a reliable, effective, and affordable hypersonic boost-glide weapons prove to be too difficult.

The CPGS weapon of most immediate concern for future nuclear reductions is likely a sea-based boost-glide weapon that the United States is developing based on its AHW. This weapon could become operational as soon as the early to mid-2020s, and although it might not have true intercontinental range, it will likely be able to reach all of Russia from forward-deployed submarines or ships. Although it does not pose a direct threat to the survivable elements of Russia's strategic nuclear forces, if deployed in large numbers and without verification to establish that they are not nuclear-armed, it risks a Russian reaction that could complicate future efforts to reduce nuclear weapons.

Although not a CPGS weapon (because they are not prompt enough) conventionally-armed subsonic cruise missiles are sometimes discussed, particularly by Russian analysts, as posing a threat similar to that of CPGS weapons. In particular, a scenario using Tomahawk cruise missiles in a zero-warning attack on Russian strategic nuclear forces is cited as a serious threat to these forces. However, there are a number of factors that make such an attack both implausible and unlikely to succeed.

Ballistic missile defenses

It has long been recognized that there are important relationships between strategic nuclear ballistic missile forces and strategic ballistic missile defenses (BMDs). During the Cold War, one concern was that unlimited BMD deployments could endanger strategic stability by threatening the effectiveness of existing nuclear ballistic missile forces, leading to a buildup of these missile forces and to a destabilizing offense-defense arms race.[39] Another concern was that even if a missile defense might be ineffective against an opponent's full nuclear ballistic missile force, it might be effective against the remnants of that force which survived a first strike attack, thus leading to dangerous pressures to attack preemptively or on warning (possibly false) in a crisis. At the same time, there were no realistic

[39] A country facing a missile defense deployment could increase the effective size of its retaliatory missile force by increasing the survivability of its ballistic missiles. However, such a size increase is ultimately limited by the total size of its nuclear missile force. It could plan to attack and destroy the defense. However, it may be difficult to ensure that the forces needed to carry out such an attack will survive the initial attack. It could deploy countermeasures on its missiles to defeat the defense. However, it may be difficult to establish with high confidence that such countermeasures will be effective. Ultimately, the highest confidence approach to preserving the retaliatory capability of a nuclear missile force is simply to increase the size of its survivable missile force so that it can overwhelm the defense. At a minimum, without a fundamental change in the way they think about nuclear weapons, it is unrealistic to expect nations to decrease the size of their nuclear ballistic missile forces if confronted by a potentially threatening BMD system.

prospects that missile defenses could ever protect the population of either the United States or the Soviet Union from a nuclear attack by very large nuclear missile forces of the other country. These considerations led the two countries to negotiate the 1972 Anti-Ballistic Missile (ABM) Treaty, which limited deployments of strategic ballistic missile defenses to token levels.

For the United States and Russia (Soviet Union), any discussions of the consequences of the deployment of BMD systems have been largely hypothetical, since they have always taken place in the context of very large existing deployments of strategic ballistic missiles. The end of the Cold War, the United States' withdrawal from the ABM Treaty, and the negotiation of the New START Treaty have so far not fundamentally changed this situation. Even after the implementation of New START, each country will retain well over 1,000 nuclear ballistic missile warheads, dwarfing the current 30+ Ground-Based Interceptors (GBIs) of the United States' GMD national missile defense system.

However, a straightforward extrapolation of United States' BMD plans shows that over the next 15-20 years the number of its strategic-capable interceptors could increase by at least an order of magnitude, to 600 or even more interceptors. If deep cuts to well below New START levels are contemplated in this context, the stability issues raised by such defensive deployments will no longer be purely hypothetical. Moreover, the nuclear plans of China will likely be strongly influenced by such defenses, even in the absence of deep reductions by the United States and Russia.

A strategic missile defense interceptor is defined here as an interceptor that is both capable intercepting an ICBM or SLBM warhead and of covering a large portion of its country (say 20-25% or more). By this definition, the U.S. Ground-Based Interceptors (GBIs) of its Ground-based Midcourse Defense (GMD) national missile defense, as well as its planned SM-3 Block IIA naval interceptors, are strategic interceptors, while the Terminal High Altitude Area Defense (THAAD) system interceptors or the Navy SM-3 Block I missiles are not strategic-capable because they cannot cover a large enough area. The 100 interceptors that both countries were permitted under the ABM Treaty and were deployed at Grand Forks (briefly) and Moscow most likely would not qualify as strategic interceptors for the same reason, but are included in the here because they have historically been viewed as strategic interceptors.

Table 2 below illustrates the situation. It shows the number of U.S. and Russian strategic ballistic missile warheads (warheads on ICBMs and SLBMs) and strategic-capable interceptors at four points in time: in 1972 when the ABM Treaty was signed; in 2002 when the United States withdrew from the ABM Treaty; in 2018 when the New START Treaty limits go into effect; and in a hypothetical year in the mid-2030s with projected U.S. strategic missile defenses (see next section) and with U.S. and Russian strategic nuclear forces reduced by a factor of two below New START levels. The final column shows the ratio of the number of U.S. and Russian nuclear missiles to the other country's number of strategic missile defense interceptors.

	US Missile Warheads	Russian Missile Warheads	US/Russian Interceptors	US/Russian Warheads per Interceptor
1972 ABM Treaty Signed	3,830	2,020	100[a]/100[a]	38.3/20.2
2002 ABM Treaty Withdrawal	4,820	4,080	0/100[a]	48.2/∞
2018 New START in Force	1,490	1,490	51[b]/100[a]	14.9/29.2
2030s ½ New START + Projected U.S. BMD	750	750	350-600[c]/?	?/2.1-1.3

[a] Number permitted by 1974 ABM Treaty Protocol.
[b] 44 GBIs + 7 SM-3 Block IIA interceptors.
[c] Low estimate = 44 GBIs + 300 SM-3 Block IIAs, high estimate = 100 GBIs + 500 SM-3 Block IIAs.

Table 2. Ratios of ballistic missile warheads to strategic-capable interceptors.

Table 2 shows that for the entire period from the signing of the ABM Treaty through entry into force of New START in 2018, Russia will never have had fewer than 29 ICBM and SLBM warheads for each U.S. strategic-capable missile interceptor. However, by about the mid-2030s this ratio could decrease to no more than about two or even less, if the ICBM and SLBM forces were reduced to half of the New Start levels. The ratio for Russia's survivable warheads (those warheads that would be expected to survive a U.S. first strike) could then be less than one.

On April 7, 2010, the day before the New Start Treaty was signed, Russia made a (non-binding) unilateral statement that indicated 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."[40] That Russia felt it necessary to make such a statement despite the then lop-sided ratio of warheads to interceptors (at that time nearly fifty to one) does not bode well for it agreeing to further cuts in the face of expanding U.S. missile defenses.

Projecting U.S. missile defenses forward in time

The current U.S. GMD national missile defense system has 30+ Ground-Based Interceptors (GBIs) deployed in silos in California and Alaska. The number of interceptors is planned to increase to 44 by the end of 2017. Although the GMD system is capable of covering all 50 states, there is a widely-held perception that, given its geometry, the system will be more effective in defending the western than the eastern United States, and there has been significant pressure from Congress to build a third interceptor site in the eastern United States. The Missile Defense Agency (MDA) has responded by beginning an environmental impact statement process for four potential deployment sites, a process that will be completed in 2016. Once this process is completed, the pressure to deploy an eastern site will only increase, and thus it is not unreasonable to expect the number of deployed GBI interceptors will eventually roughly double, to about 90-100.[41]

[40] U.S. Department of Defense, "New Start: Article-by-Article Analysis Unilateral Statements," no date. Available at: http://www.acq.osd.mil/tc/treaties/NST/Art%20By%20Art/art_uni_statements_annex.htm.
[41] The Missile Defense Agency's environmental impact statement materials state that each site will be assessed for a deployment of up to 60 interceptors. See: http://www.mda.mil/global/documents/pdf/CIS_about_public_meeting.pdf.

The capacity – that is, the number of attacking warheads it is able to attempt to destroy – of the current GMD system is quite low. Because of the low reliability that the GBI interceptors have so far demonstrated, the current firing doctrine calls for launching roughly four interceptors at each incoming missile, resulting in a system capacity of only about ten. However, the MDA is taking steps to increase the capacity of the system by improving both its interceptors' reliability and the overall system's effectiveness.

The MDA has stated that it can double the capacity of the GMD system simply by improving the reliability of its interceptors. By 2020, the MDA plans to begin deployment of a new Redesigned Kill Vehicle with a modular design which is intended to have a much higher reliability than the current kill vehicle. A new, more reliable version of the interceptor rocket booster is also scheduled for 2020.

The MDA is also developing a two-stage version of the current three-stage interceptor that is intended to enlarge the BMD system's "battlespace" by allowing later intercepts. This could enable more efficient interceptor firing doctrines, such as a shoot-look-shoot strategy, which could further improve the capacity of the system.[42]

In addition, the MDA is taking steps to make the GMD system more effective by increasing its ability to correctly identify and destroy the actual warhead. The current GMD system has only a single long-range discrimination radar, the Sea-Based X-band (SBX) radar, which operates out of Honolulu. The SBX was built primarily for testing purposes and has significant operational limitations, most importantly a very limited range of electronic scan angles. By 2020, the MDA plans to build a new Long-Range Discrimination Radar in Alaska. Following this deployment, the MDA plans to provide a discrimination radar for the East Coast, either by relocating the SBX or by building a new radar. By the mid to late 2020s, the MDA also plans to deploy a new Multiple Object Kill Vehicle, which is intended to reduce the system's vulnerabilities to decoys by hitting each credible object released from a missile with a separate small kill vehicle.

Taken together, these planned improvements could increase the capacity of the GMD system by about a factor of five, to 50 or more, assuming an east coast site is built.

However, these Ground-Based Interceptors are only a part of the future U.S. strategic-capable BMD system. In terms of numbers, these GBIs are much less significant than the planned deployments of strategic-capable, high-speed naval interceptors. The fourth phase of the Obama administration's original European Phased Adaptive Approach (EPAA) plan, scheduled for 2020, would have deployed high-speed (about 5.0-5.5 km/s) SM-3 Block IIB interceptors at an Aegis Ashore site in Poland. These missiles were not intended for a defense of Europe, but rather for providing an additional defense of U.S. territory against Iranian ICBMs.[43] However, citing delays in the program, the Department of Defense cancelled the SM-3 Block IIB program in 2013. Instead, the very similar, but somewhat slower (about

[42] In a shoot-look-shoot approach, the defense observes the outcome of the first intercept attempt before deciding whether or not to fire additional interceptors. This strategy allocates interceptors more efficiently than the current salvo firing doctrine, in which all interceptors are launched before the outcome of the first intercept attempt is known.

[43] Aegis Ashore is a near duplicate of the Aegis combat system on U.S. Navy destroyers and cruisers, except that it is built on land. Each Aegis Ashore site will initially include 24 launchers. Aegis Ashore will be equipped only for the Aegis ballistic missile defense mission, and will not have the anti-aircraft or Tomahawk missile capabilities that the system on the ships has. Giving an Aegis Ashore site the capability to launch Tomahawk missiles would violate the INF Treaty. (Russia has argued that Aegis Ashore is a violation even without this capability.)

4.0-4.5 km/s) SM-3 Block IIA interceptors will be deployed in Poland on the same schedule, following their initial deployment at the Romanian Aegis Ashore site beginning in 2018.

The Block IIA interceptor is not fast enough to intercept Iranian (or Russian) ICBMs launched towards U.S. territory from the planned European Aegis Ashore sites, since the ICBMs will fly too high for the interceptor to reach. However, if deployed near U.S. shores or on U.S. territory at Aegis Ashore sites, Block IIA interceptors can intercept ICBMs headed to U.S. territory over most of the descending part of their trajectories.[44]

The significant role that Block IIA could play in defending U.S. territory is not as widely appreciated as it should be. However, as shown in Figures 3 and 4 both critics and supporters of U.S. national missile defenses have published the results of analyses showing that such interceptors could cover the entire United States against ICBMs.

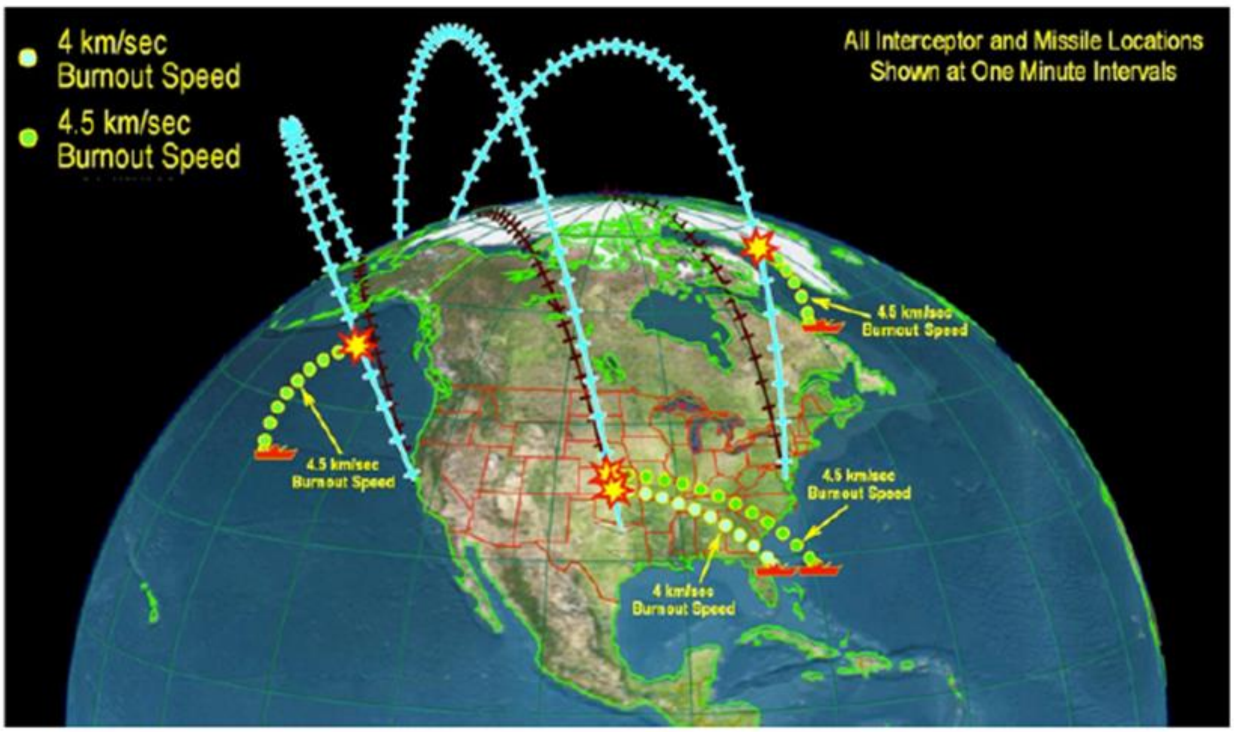

Figure 3. ICBM trajectories and intercept trajectories for SM-3 Block IIA missiles with speeds of 4.0 and 4.5 km/s, from a 2011 Federation of American Scientists Report by Yousaf Butt and Theodore Postol.[45] This figure illustrates how the entire continental United States could be covered against ICBMs with SM-3 Block IIA interceptors launched from just a few ships.

---

[44] 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. Available at: http://www.nap.edu/catalog/13189/making-sense-of-ballistic-missile-defense-an-assessment-of-concepts.

[45] Figure 4 of 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, available at: http://fas.org/pubs/_docs/2011%20Missile%20Defense%20Report.pdf).

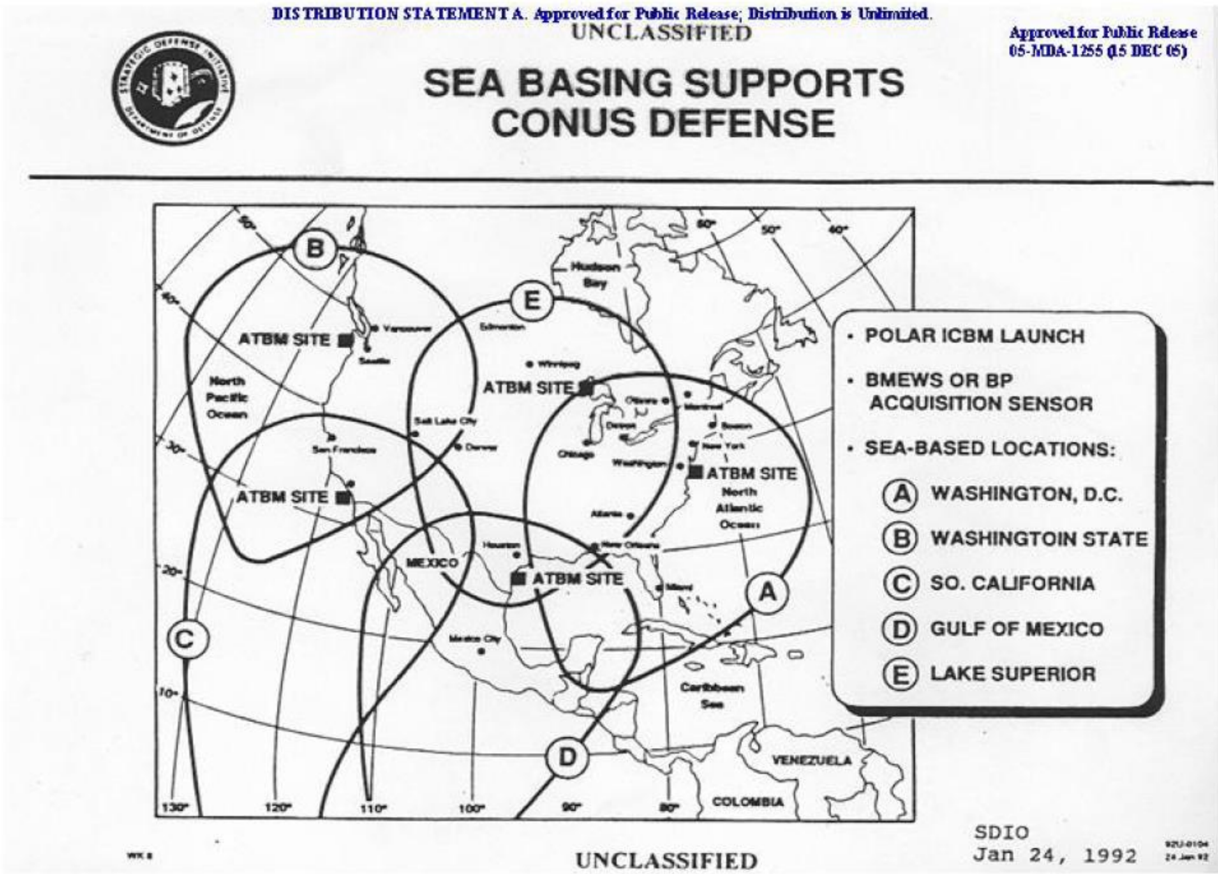

Figure 4. Strategic Defense Initiative Organization map from 1992 showing coverage of the United States by SM-3 Block IIA-like naval interceptors.[46]

The United States currently plans to buy 182 Block IIA interceptors just to support the EPAA through 2040.[47] These interceptors would 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. Not all of these Block IIA missiles would be deployed at the same time, as the lifetime of the missile is only twelve years, but the total deployed at any one time will likely be between 96 and 144. Similar or even larger numbers of Block IIA interceptors could be deployed on the seven U.S. Aegis BMD ships currently based in Japan.[48]

[46] This is Figure 2 (p. 5) of Rear Admiral A. Brad Hicks, "Aegis Ballistic Missile Defense (BMD) System," Washington Roundtable on Science and Public Policy, George C. Marshall Institute, December 2005. Available at: http://missilethreat.com/wp-content/uploads/2012/10/Aegis-Ballistic-Missile-Defense-System.pdf.

[47] Justin Doubleday, "Pentagon Will Buy Extra Block IIA Interceptors for European Missile Shield, *Inside Defense SITREP*, August 4, 2015.

[48] Although the medium to long-range missile threat from China is greater than that from Iran, the U.S. ships based in Japan will eventually be supplemented by eight Japanese Aegis BMD ships. Japan will be co-producing the Block IIA interceptors, 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.)

These eleven ships in Spain and Japan are only a third of the U.S. Navy's current total of 33 BMD deployable ships, a number that is expected to rise to 39 by 2020 and to continue to increase afterwards.[49] According to the Navy, the requirement for "advanced" capability Aegis BMD ships is 40, a figure that will not be reached until 2026.[50] ("Advanced" BMD ships can perform air defense and missile defense simultaneously; other Aegis BMD ships can only be configured for one or the other. Only about three of the current 33 BMD ships have this "advanced" capability.[51]) The number of requests from the regional Combatant Commanders for Aegis BMD ships is even larger, currently 77 ships. As shown In Figure 5, assuming that the Navy continues to procure two Aegis destroyers per year, the number of BMD capable ships will exceed 60 by 2030 (all new production Aegis destroyers will be fully equipped with the advanced BMD capability).

---

[49] Sam LaGrone, "MDA Quietly Revises Projected Ballistic Missile Defense Ship Total Down from FY 2016 Budget Request, USNI News, September 1, 2015. Available at: http://news.usni.org/2015/09/01/mda-quietly-revises-projected-ballistic-missile-defense-ship-totals-down-from-fy-2016-budget-request.

[50] Ronald O'Rourke, "Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress," Congressional Research Service Report RL-33745, December 11, 2015, p. 15. Available at: http://fas.org/sgp/crs/weapons/RL33745.pdf.

[51] Currently, ships without the advanced capability do not have the have the computer software required to operate the SM-3 Block IIA missiles. However, the four destroyers stationed in Rota, Spain as part of the EPAA do not have the advanced BMD capability and there are no plans to give them this capability, suggesting that ships without the advanced capability can receive software upgrades necessary to operate the Block IIA missiles once these missiles are deployed beginning in 2018. An upgrade of this type was apparently used to give at least some ships with the "basic" BMD capability (which included the SM3-Block IA missile) the ability to use Block IB missiles.

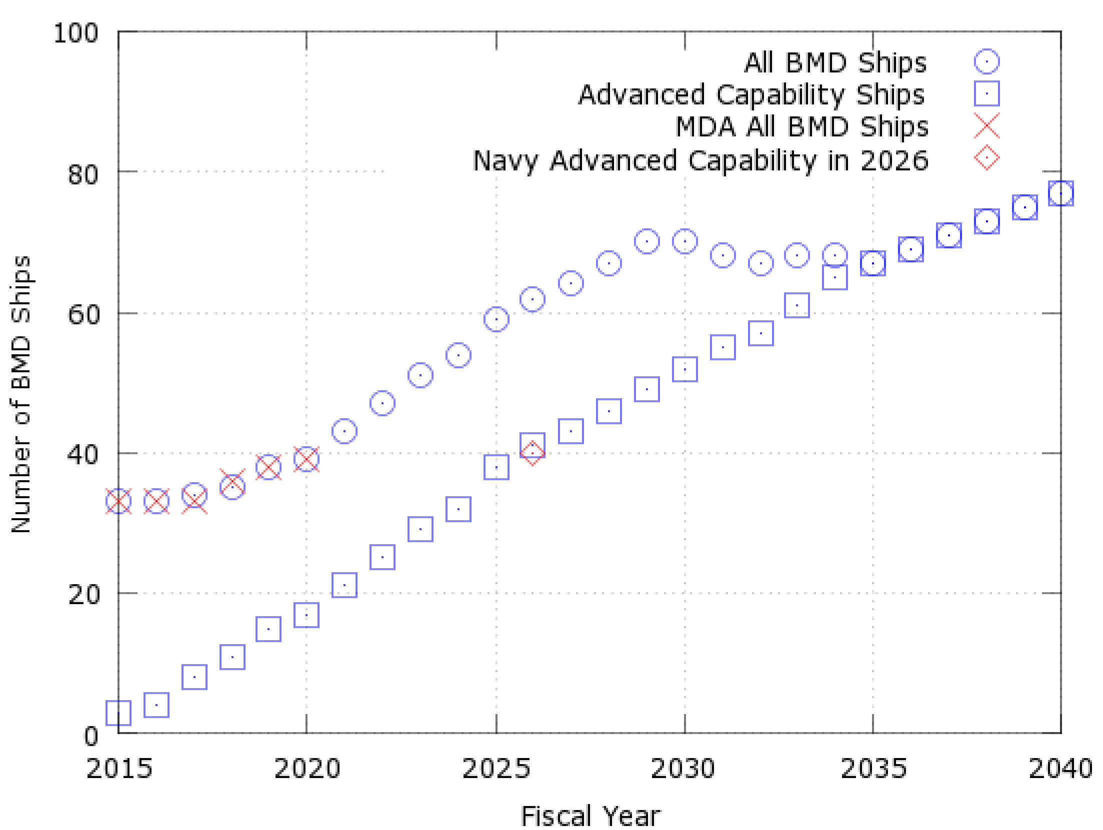

Figure 5. Projected (by author) number of Aegis BMD ships through 2040. The red Xs show the Missile Defense Agency's projection through 2020 and the red diamond shows the U.S. Navy's projection that it will have 40 advanced BMD capability ships in 2026. For details on this projection, see http://mostlymissiledefense.com/2015/12/13/how-many-aegis-bmd-ships-in-2040-december-13-2015/.

Deliveries of SM-3 interceptors have been steadily increasing, and current plans call for the delivery of 71 missiles in FY 2019 and 76 in FY 2020. Although most of these will be slower SM-3 Block IB missiles, production can be expected to switch over primarily or exclusively to Block IIA interceptors in the early 2020s. (Production of the earlier Block IA missiles has already ended and these are being phased out as they reach their service lifetimes.) Relative to the Block IB missile, the Block IIA allows much greater ship positioning flexibility and allows each ship to defend a much larger area, as illustrated in Figure 6 below. Thus, although Block IIA missiles will likely cost roughly twice as much as Block IB missiles, there are strong operational reasons for the Navy to prefer future procurements of Block IIA missiles over more Block IB missiles.

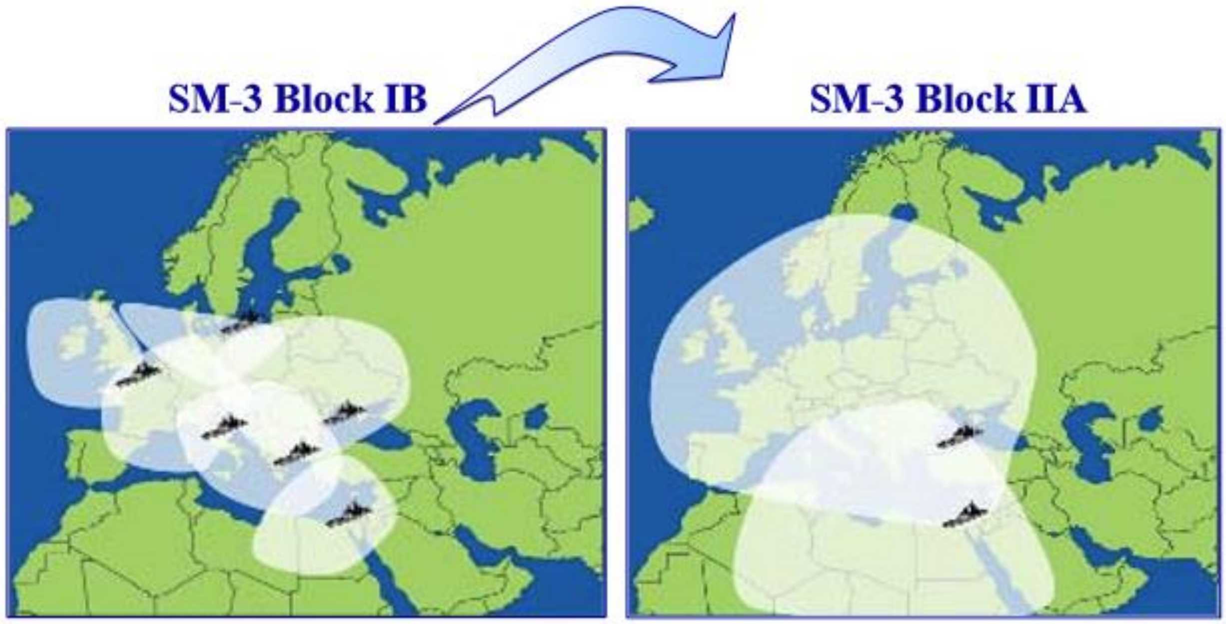

Figure 6. The greater speed (about 50% faster) of the Block IIA relative to the current Block I interceptors will give ships with the Block IIA much greater flexibility in their choices of operational areas and will significanly reduce the number of ships (or Aegis Ashore sites) needed to cover a given area. Missile Defense Agency image.[52]

Figure 7 below is a projection of the number of U.S. SM-3 Block IIA interceptors through the next twenty years. It shows that the number of Block IIA interceptors could exceed 500 by the mid-2030s. The actual numbers could be higher. Thus by the mid-2030s, if current trends continue, the United States could have more than 600 strategic-capable BMD interceptors (100 GBIs + 500+ SM-3 Block IIAs).

[52] From slide "Greater Missile Reach Increases Defended Area," in Missile Defense Agency Briefing, "Aegis Ballistic Missile Defense: Status, Integration and Interoperability," May 6, 2008. Available at: https://mostlymissiledefense.files.wordpress.com/2013/09/2008-5-aegisbmd-statusintergrationandinteroperability.pdf.

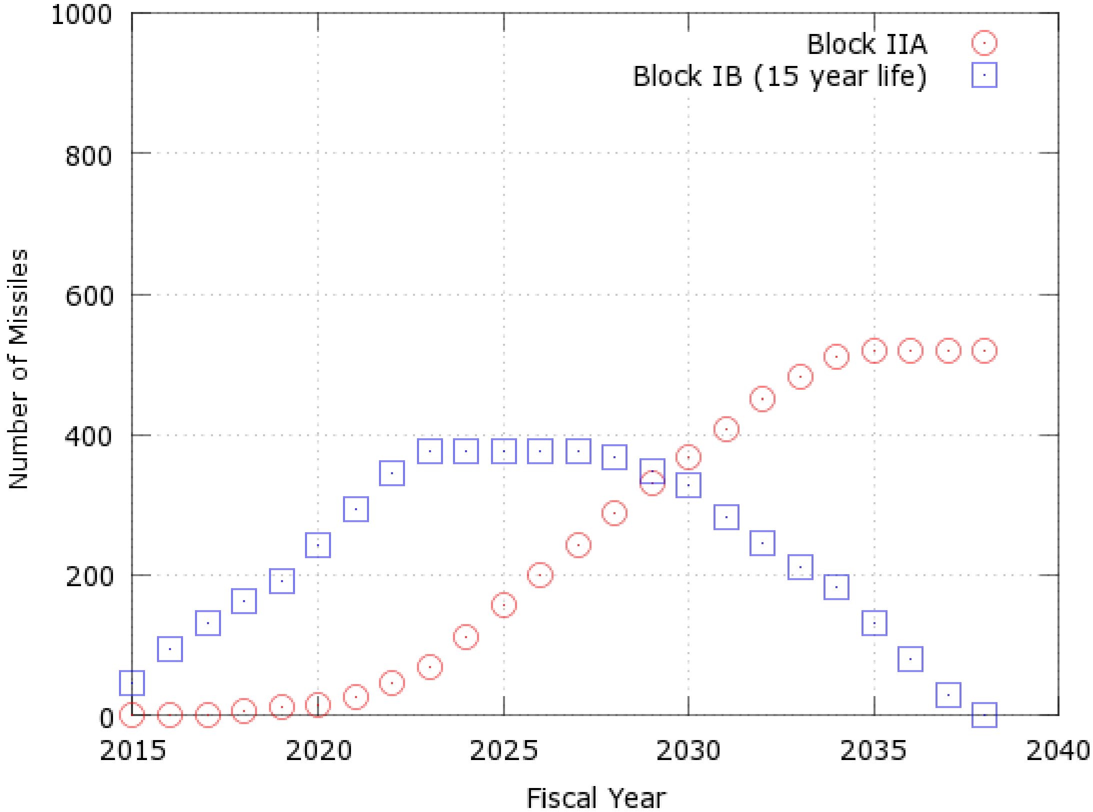

Figure 7. Projection (by author) of the number of SM-3 Block IB and SM3 Block IIA missiles in U.S. inventory. For details of this projection, see http://mostlymissiledefense.com/2016/01/25/how-many-sm-3-block-iia-missiles-january-25-2016/.

These hundreds of interceptors would be supported by an integrated sensor system spanning the entire Northern Hemisphere, as shown in Figure 8 below.

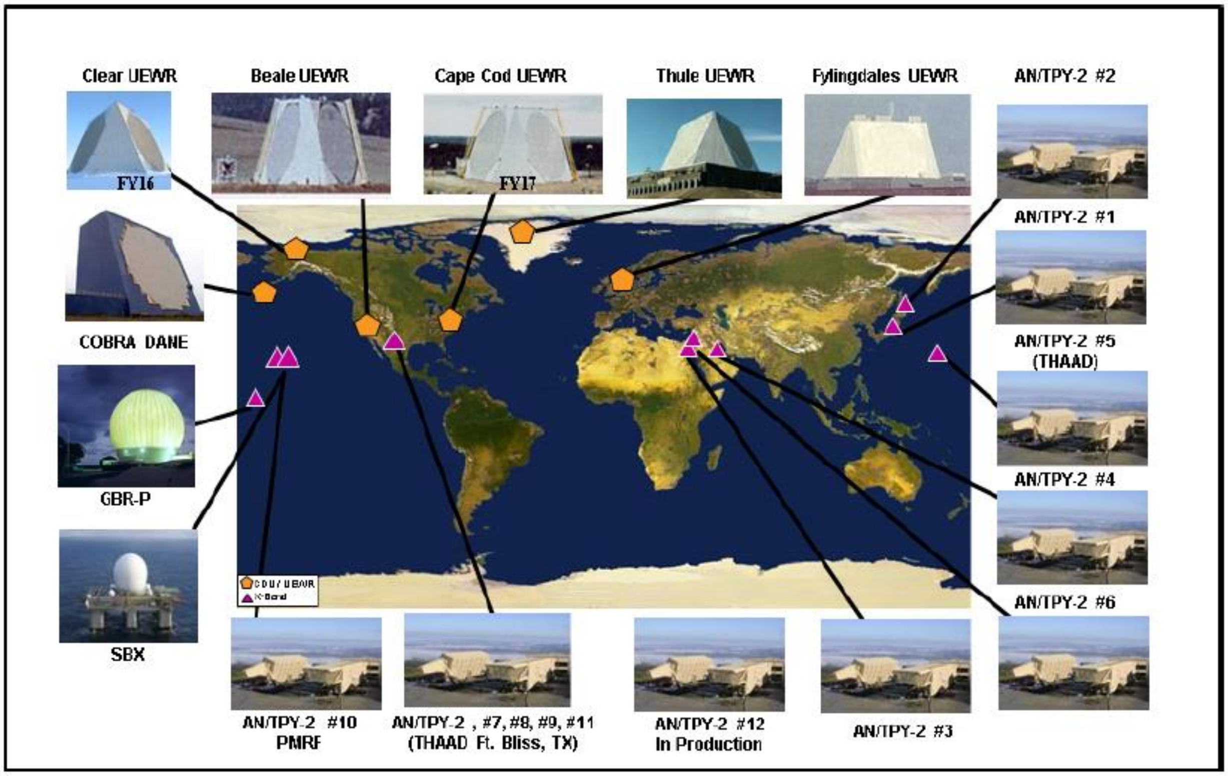

Figure 8. The radar sensor network for the U.S. BMD system spans the northern hemisphere. Aegis radars on ships and at Aegis Ashore sites not shown. Missile Defense Agency Figure.[53]

From a Russian perspective, one of the more disturbing aspects of the U.S. BMD program is that it is completely open-ended. There is no objective or final system that Russia and other countries can plan for. Potential upgrades that could be initiated in the 2020s include a higher-speed version of the SM-3 Block IIA interceptor (higher speed is desirable because it increases the operational flexibility of U.S. naval forces, but it would also allow intercepts of Russian and Chinese missiles almost anywhere along their trajectories); an extended-range version of the THAAD interceptor, which could give it strategic capabilities; additional discrimination radars; a space-based tracking system; and air-borne lasers for discrimination.

A transition to defense dominance?

Some missile defense supporters claim that extensive BMD deployments are not only compatible with a world without nuclear-armed ballistic missiles, but that they could actually help achieve and stabilize

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

such a world.[54] They argue that BMD could break up a disarming first strike, thereby in turn allowing for further nuclear missile reductions, which in turn would make the missile defenses more effective. If the United States and Russia were to follow such an approach in tandem, they argue that this could lead to significant reductions in their ballistic missile forces. BMD supporters also point out that missile defenses can facilitate nuclear reductions by reducing concerns about the proliferation of potential nuclear missile states such as North Korea or Iran. Moreover, if an agreement could be reached to eliminate nuclear ballistic missiles, BMD could play a stabilizing role by reducing concerns that a country might break out of the regime by rapidly deploying a small number of nuclear missiles.

The most glaring problem with these arguments is how the transition to such a BMD-dominant world could be accomplished. Today, nuclear-armed ballistic missiles are the primary means that all nuclear-armed states rely on for nuclear deterrence. As long as this continues to be the case, any serious threat to a nation's nuclear ballistic missile force will require a response to preserve that force's retaliatory capability. Almost by definition, at some point in a process of transition to a BMD-dominant world, a point will be reached in which a country loses confidence in the future retaliatory capability of its nuclear missile forces. If that country has not already abandoned its reliance on nuclear-armed missiles for deterrence, it will react to preserve this capability, assuming it has the resources to do so. In order for a transition to defense dominance to be viable, countries must abandon their reliance on nuclear armed missiles for deterrence *before* defenses expand to the point of being able to threaten those missile forces. Unless such an abandonment occurs, an unlimited process of expanding strategic missile defenses must at some point bring the process of reducing nuclear forces to a halt.

At present, there is no indication that any nuclear weapons state is willing to give up its reliance on nuclear-armed missile for deterrence. Meanwhile, over the next two decades the U.S. missile defense program is on track to expand its force of strategic-capable interceptors by more than an order of magnitude. Unless one of these factors changes, there is a very strong likelihood that the U.S.-Russian process of reducing their nuclear forces will stall at levels well above those at which other countries would be willing to join in at.

BMD effectiveness and uncertainty

Large-scale deployments of strategic-capable BMDs are likely to introduce a great deal of uncertainty and variability into assessments of strategic deterrent relationships, for several reasons.

The actual effectiveness of a BMD system is likely to be primarily determined by its capability to counter steps taken by an adversary to defeat it. Such steps, collectively referred to as "countermeasures," are not just a hypothetical possibility. Every country that has deployed an intercontinental ICBM or SLBM has had an extensive, parallel, and highly secretive program to develop and test countermeasures for their missiles.[55]

---

[54] For example, see Dean A. Wilkening, "Nuclear Zero and Ballistic Missile Defense," *Survival*, Vol. 52, No. 6 (December 2010-January 2011), pp. 107-126.

[55] See Andrew M. Sessler, John M. Cornwall, Bob Dietz, Steve Fetter, Sherman Frankel, Richard L. Garwin, Kurt Gottfried, Lisbeth Gronlund, George N. Lewis, Theodore A. Postol, and David C. Wright, *Countermeasures* (Cambridge, MA: Union of Concerned Scientists and MIT Securities Studies Program, 2000), Chapter 5 and Appendix E. Available at: http://www.ucsusa.org/sites/default/files/legacy/assets/documents/nwgs/cm_all.pdf.

There are many possible types of countermeasures, relying on many different mechanisms, which can be used to defeat defenses, and these can be used separately or in combination. Although countries can attempt to learn about other countries' countermeasures and counter-countermeasures programs by observing tests, the secrecy associated with programs and tests will inevitably mean that each country at best has incomplete information about the programs of other countries.[56]

The most visible indicator of how a well a ballistic missile defense might work is its test record. Yet test records can be highly misleading. The first combat use of a BMD system was the use of the Patriot system in the 1991 Gulf War. Despite a perfect test record (17 successful intercepts in 17 attempts), Patriot failed completely against the Iraqi Scuds.[57] This failure occurred because the Iraqi Scuds differed in important ways from the targets that Patriot had been tested against. Specifically, the Iraqi missiles broke apart and maneuvered vigorously in the atmosphere, whereas the test targets flew on stable and slower trajectories.

A BMD system's test record can mislead in the opposite direction. The intercept test record of the U.S. GMD national missile defense system is relatively poor – nine successful intercepts out of seventeen attempts.[58] Despite this test record, U.S. government and military leaders have repeatedly stated that the system would highly effective if ever used – according to MDA Director Lt. Gen. Patrick O'Reilly in 2010 the probability of intercepting an Iranian missile would "be well in the high 90s."[59] Almost all of the failures in these tests have been due to quality control issues (a part omitted during assembly, a blocked cooling line, etc.) and not due to any fundamental flaw with the interceptor.[60] The MDA has made the elimination of such quality control errors a top priority, and since these intercepts tests are essentially carefully designed and highly scripted demonstrations intended to validate simulations, once such quality control problems are eliminated or greatly reduced, the GMD intercept test record is likely to greatly improve. Such a development would significantly boost some opinions of the GMD system's effectiveness, both within and outside the United States, despite the fact that any opinions about the system's effectiveness are essentially meaningless without knowing the extent to which the system has been tested against potentially effective countermeasures. Yet it is implausible that the MDA would ever conduct a test using a countermeasure that it expected would defeat the system.[61]

---

[56] All details of countermeasures used in tests of the U.S. GMD national missile defense program have been classified since 2002. Kerry Gildea, "MDA Classifies Missile Defense Flight Test Target, Countermeasure Data," *Defense Daily*, May 15, 2002.

[57] George N. Lewis and Theodore A. Postol, "Video Evidence on the Effectiveness of Patriot during the 1991 Gulf War," *Science and Global Security*, Vol. 4, No. 1 (1993), pp. 1-63. Available at: http://scienceandglobalsecurity.org/archive/sgs04lewis.pdf.

[58] U.S. Missile Defense Agency, "Ballistic Missile Defense Intercept Flight Test Record," Fact Sheet, December 10, 2015. Available at: http://www.mda.mil/global/documents/pdf/testrecord.pdf.

[59] Strategic Forces Subcommittee of the House Armed Services Committee, December 1, 2010. For a list of official U.S. statements about the effectiveness of the U.S. GMD system, see George Lewis, "Updated List of Claims About GMD Effectiveness (June 16, 2015)." Available at http://mostlymissiledefense.com/2015/06/16/updated-list-of-claims-about-gmd-effectiveness-june-16-2015/.

[60] The one exception that caused the failure of the FTG-06a test In December 2010 led to a three and a half year delay in demonstrating the capability of an upgraded version of the interceptor kill vehicle.

[61] Officially, all intercept tests of the GMD system since 2008 have employed "countermeasures," and all future intercept tests will also do so. However, there is no public evidence that any of these test used a countermeasure that the GMD system could not easily defeat using the detailed advance knowledge of the nature of the target set that it is provided with.

Uncertainties regarding BMD effectiveness will be exacerbated by the fact that there has never been an actual combat intercept of a long-range ballistic missile by an above-the-atmosphere interceptor such as the GMD system's GBI interceptor or an Aegis SM-3 interceptor. In addition, the possibility of a direct attack on the defense system adds further complexity and uncertainty to any assessment of the deterrent capabilities of a nuclear ballistic missile force. In the absence of any real information about the nature of countermeasures that an attacker might employ and of the ability of the defense to defeat them, assessments of the effectiveness of a defense may have little meaning, and could be driven by worst-case analysis to very divergent conclusions.

These differing assessments of the defense system will likely extend beyond the expectations of its effectiveness to include the actual size of the defense. For example, Russia and China are likely to include all of the U.S. high-speed naval interceptors in their assessments of the balance between defenses and strategic missile forces, while the United States is unlikely to include any that have not been explicitly designated for defense of U.S. territory. Similarly, Russia and China are likely to have different assumptions than the United States about how many interceptors will be fired at each incoming warhead.

The uncertainty introduced by BMD is in sharp contrast to that involved in assessing the damage that could be inflicted by a nuclear ballistic missile force. In the absence of BMD, the primary uncertainly is likely to be in the pre-launch survivability of the missiles. Once launched, a ballistic missile fired by a well-established and tested missile force will almost certainly perform as expected. For example, the U.S. Trident II SLBM has been successfully flight tested more than 150 consecutive times since 1989.[62] This allows a country that has even a relatively small number of survivable nuclear missiles to be highly confident that they will be able to inflict unacceptable damage. The uncertainly produced by introducing missile defenses into an otherwise certain nuclear deterrence relationship can only lead countries to be more cautious about reducing the size of their nuclear forces.

Would Russia be willing to reduce further in the face of a U.S. missile defense force such as that outlined above?

As discussed earlier, Russia could reduce its number of New START accountable warheads by a factor of at least two without increasing the vulnerability of its forces by partially deMIRVing its ICBMs and SLBMs, giving it a total of about 750 missile warheads.[63] If between half and two-thirds of its missile warheads are survivable, then Russia would have roughly 400-500 survivable missile warheads. Assuming that the state of relations is such that Russia and the United States could consider further nuclear reductions, would Russia be willing to reduce this far in the presence of a U.S. missile defense system that could have more strategic-capable interceptors deployed than Russia has survivable missile warheads? And how might China respond to such U.S. defenses?

The official U.S. position is that its GMD national missile defense system is not capable of defending against Chinese or even Russian nuclear forces, both because those forces are too large and because Russia and China can develop and deploy countermeasures to defeat the defenses. At least a significant fraction of the scientists and military experts in all three countries might agree with this argument.

[62] "Navy's Trident II D5 Missile Marks 155 Successful Test Flights." February 23, 2015. http://www.lockheedmartin.com/us/news/press-releases/2015/february/ssc-space-trident.html.
[63] Presumably a similar reduction would be imposed on the bomber forces, perhaps by changing their counting rules.

However, the United States rarely if ever officially acknowledges that its planned naval BMD deployments have any capability at all against even a single Russian or Chinese missile.

The argument that U.S. missile defenses do not pose a threat may be a very difficult argument to sell to political leaders and the public in Russia and China. They will see a U.S. missile defense program that looks disproportionately large for the threat it is supposedly intended to counter. While North Korea and Iran may have hundreds or thousands of missiles, the vast majority of these are shorter-range missiles better countered with defense systems such as Patriot or THAAD.[64]

They will also see U.S. officials repeatedly stating that the system is highly effective and will see that it has been repeatedly tested against targets employing (classified) countermeasures. U.S. officials might qualify these claims by stating that they apply to North Korean and Iranian missiles, which will have only simple countermeasures. Yet as far back as 1999, the U.S. Intelligence Community had concluded that Russia or China "probably are willing to sell" their countermeasures technology to such countries.[65]

Russian and Chinese leaders may conservatively tend to overestimate the capabilities of the U.S. BMD system. But they may also be concerned that U.S. leaders may not understand the limitations of the system, and behave as if they have a large and highly effective system.

In addition, as noted above, the U.S. is continuing to enhance the capability of the GMD system to cope with countermeasures, including deploying a new discrimination radar and developing the new Multiple Object Kill Vehicle to allow a single interceptor to attack both warheads and decoys. The U.S. missile defense program will likely remain open-ended, with the U.S. continuing to spend billions of dollars per year to expand the system and enhance its effectiveness.

There is no way to know with any certainty how far Russia might be willing to reduce their strategic ballistic missile forces in the face of a rapidly expanding U.S. BMD system. But the point at which the number of strategic-capable interceptors equals the number of survivable Russian missile warheads could be a significant psychological barrier. As argued above, this point could be reached by about the mid-2030s if U.S. and Russian ballistic missile forces are reduced below New START levels.

It is also important to note that Russia has significantly modernized its strategic nuclear forces, and the number of missile warheads it is capable of deploying is expected to continue to grow at least into the mid-2020s. Thus Russia no longer has the incentive to agree to lower numbers simply to maintain parity with the United States in numbers of strategic warheads, an incentive that it has had over the last twenty years.[66] It is far from clear that Russia has any incentive to further reduce its nuclear forces in the face of a rapidly growing U.S. BMD system that is being deployed, along with advanced conventional weapons, over its objections.

A crucial factor in determining the future course of missile defense deployments and nuclear reductions may be that the United States simply does not seem to take Russian and Chinese concerns about missile defenses seriously. Unless this changes, the likely outcome is that the United States will simply continue

---

[64] Many of these shorter-range missiles will not rise far enough out of the atmosphere to be intercepted by Aegis SM-3 or GBI interceptors.

[65] National Intelligence Council, "National Intelligence Estimate (NIE): Foreign Missile Development and the Ballistic Missile Threat to the United States Through 2015," unclassified summary, September 1999. Available at: http://www.au.af.mil/au/awc/awcgate/cia/nie99msl.htm.

[66] Kristensen and Norris, "Russian Nuclear Forces, 2015," note that if the New START Treaty is extended, Russia will probably have to reduce the number of warheads on its ICBMs or SLBMs to stay under the Treaty's limits.

to build up its missile defense system until it provokes a strong reaction from one or both countries. Some of the most obvious forms such a Russian reaction could take, from it refusing to go below New Start levels, to refusing to extend the Treaty and building up its forces, to deploying its own national missile defense system, would be a severe setback for any efforts to reduce U.S. and Russian nuclear arsenals. Such reactions would only reinforce the connection between strategic missile defenses and strategic offensive missile forces. Moreover, by the time the reaction occurs, U.S. BMD deployments may be at or approaching a level that would preclude Russian reductions much below New Start levels for the indefinite future.

To avoid blindly walking into such a situation, it might be useful for Russia and China to spell out explicitly how they expect to respond to a given level of defense deployments well before those deployments occur.

US BMD and China

The interaction between the U.S. BMD program and China's ballistic missile forces could also have significant adverse consequences, for at least two reasons.

First, the best available estimate is that China currently has about 64 ICBM warheads capable of reaching at least as far as the U.S. West Coast, about half of which are deployed in vulnerable land-based silos.[67] The U.S. intelligence community estimates that this number could increase to well over 100 by the mid-2020s.[68] China also has four nuclear ballistic missile submarines (SSBNs), each capable of carrying twelve single-warhead missiles, although this missile has not yet entered service. In order to bring its missiles within range of the U.S. West Coast, a Chinese ballistic missile submarine would need to conduct a deterrent patrol well beyond its home port.

Today, China's number of survivable nuclear warheads capable of reaching at least the U.S. West Coast is roughly comparable to the number of U.S. strategic-capable interceptors. Although this number of Chinese warheads is expected to slowly increase, it is not likely to keep pace with the rapid increase in the number of U.S. strategic-capable warheads beginning in about 2020.

In this context, it is striking that earlier this year the United States announced that China had begun to deploy MIRVed warheads on some of its silo-based DF-5 ICBMs.[69] China has been capable of MIRVing its missiles for decades, but had refrained from doing so, and this development is widely viewed as being at least in part a response to the U.S. BMD program.[70] A second, road-mobile, MIRVed ICBM is also under development, and was first flight tested in August 2015.[71] Thus the U.S. BMD program may already be

---

[67] Hans M. Kristensen and Robert S. Norris, "Nuclear Notebook: Chinese Nuclear Forces, 2015," *Bulletin of the Atomic Scientists*, Vol. 71, No. 4 (2015), pp. 77-84. Available at: http://bos.sagepub.com/content/71/4/77.full.pdf+html.

[68] Ibid.

[69] David E. Sanger and William J. Broad, "China Making Some Missiles More Powerful," *New York Times*, May 16, 2015. Available at: http://www.nytimes.com/2015/05/17/world/asia/china-making-some-missiles-more-powerful.html.

[70] Ibid.

[71] Statement of Admiral C. D. Haney, Commander, U.S. Strategic Command, before the Senate Armed Services Committee, March 19, 2015. Available at: http://www.armed-services.senate.gov/imo/media/doc/Haney_03-19-15.pdf. Bill Gertz, "China Tests New Long-Range Missile with Two Guided Warheads," *Washington Free Beacon*, August 18, 2015.

influencing China to build up its long-range nuclear ballistic missile forces faster than it otherwise would have.[72] In addition, the first deterrent patrol of a Chinese ballistic missile submarine apparently took place in late 2015.[73]

Second, many U.S. officials and analysts have expressed great concern about new Chinese conventionally-armed ballistic missiles, the DF-21D and the DF-26C. These so-called "carrier killer" missiles are believed to be equipped with a maneuvering warhead with terminal guidance. The deployment of this and other missiles raises the prospect of an offense-defense competition as the U.S. expands its missile defense capabilities in Asia. Such a competition could then feed back into Russian concerns if it leads the United States to deploy significantly larger numbers of naval SM-3 Block II interceptors which could be rapidly redeployed to defend U.S. territory. Both new Chinese missiles are believed to be conventional variants of nuclear-armed missiles.

What can be done to mitigate the impact of defense deployments?

Are there steps that could plausibly be taken to reduce the impacts that large-scale missile defense deployments will have on the prospects for future reductions in U.S.-Russia nuclear forces? Reviewing a list of possible approaches mostly only emphasizes the difficulty of the challenge.

Reduce the threat. If either or both of the nuclear and missile programs of Iran and North Korea could be shut down or greatly curtailed, for example, to only short-range missiles, then much of the justification (at least the publicly stated justification) for U.S. strategic-capable BMD systems would disappear, which might allow the U.S. to restrain their deployments. To the extent that Russia and China believe this is possible it would be in their interests to help curtail the North Korean and Iranian missile programs.

Cooperation on defenses. U.S.-Russian cooperation on missile defenses has often been proposed, but little has come of these proposals. Some forms of cooperation, for example on ballistic missile warning, might be useful as confidence-building measures. However, the threat that U.S. BMD systems pose to Russian or Chinese nuclear ballistic missile forces could only be eliminated by giving them a veto over the use of the BMD systems, which is not possible today or likely in the foreseeable future.

In 2014, the United States suspended all missile defense cooperation with Russia. The Missile Defense Agency's website 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.[74]

U.S. unilateral restraint on missile defense deployments. For the foreseeable future, there appears to be little possibility that the United States would agree to any negotiated limits on its missile defenses.

---

[72] The MIRVing of these missiles does not immediately allow China to greatly increase the number of its missile warheads, since the limited payloads of these missiles means that each one can carry at most only two or three warheads. See David Wright, "Groundless Claims about Chinese MIRVing," All Things Nuclear blog, October 9, 2015. Available at: http://allthingsnuclear.org/category/missiles-missile-defense#.Vngz44-cGM8.
[73] Bill Gertz, "Pentagon Confirms Patrols of Chinese Nuclear Missile Submarines," *The Washington Times*, December 9, 2015. Available at: http://www.washingtontimes.com/news/2015/dec/9/inside-the-ring-chinas-nuclear-missile-submarine-p/?page=all.
[74] U.S. Missile Defense Agency, "International Cooperation," no date. Available at: http://www.mda.mil/system/international_cooperation.html.

Nevertheless, it might be possible for it to take steps unilaterally to limit the threat posed by BMD as perceived by Russia and China.

For example, the United States could decide to either reduce the number of SM-3 Block IIA interceptors it intends to buy or take steps to limit its geographic scope of their deployments. Reducing the number of Block IIA interceptors, perhaps in favor of more of the slower Block IB interceptors, would reduce the total number of strategic-capable interceptors that could threaten Russia's ballistic missile forces. However, 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 the Block IIA missile relative to the Block IB missile, it seems highly unlikely that the U.S. would restrain Block IIA numbers to levels small enough to significantly reduce the perceived threat they would present to Russia and China.

The U.S. Navy could also 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. Recall that Block IIAs can only intercept Russian or Chinese ICBMs after the peak of their trajectories as they descend towards their targets. 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 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 U.S. 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.

Other delivery systems. If Russia (and China) could develop intercontinental-range boost-glide vehicles, they could deploy nuclear weapons on a significant number of these. For example, Russia could replace the nuclear warheads on its mobile ICBMs or some of its SLBMs with nuclear boost-glide vehicles. Current and planned U.S. BMD systems would have little or no capability against such missiles. Intercontinental boost-glide weapons are very high technology weapons that require extensive testing, and it is unlikely that Iran or North Korea could deploy such weapons for many years. Thus in principle the U.S. might not feel compelled to respond to such deployments of Russian boost-glide weapons.

Alternatively, Russia could place more emphasis on nuclear bombers, and in particular on ones carrying nuclear cruise missiles. This would require a very significant shift in their nuclear force postures. Moreover, such augmented cruise missile forces might not replace their ballistic missile forces, but only add to them.

Russia (and China) could deploy its own strategic BMD system. Such a system could potentially enhance the number of survivable strategic missile warheads in Russian calculations by destroying U.S. missiles attempting to destroy them in a first strike. 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.

Incorporate BMD systems into nuclear arms agreements. Some have suggested incorporating defense interceptors in future arms reduction agreements by trading off BMD interceptors for nuclear missile warheads. There are several problems with this idea, but the most fundamental one is that since the U.S. does not see its BMD program as part of the nuclear balance with Russia, its gains nothing from such a tradeoff. It would require the United States to accept both a lower number of nuclear weapons than Russia and limits on the number of its BMD interceptors, neither of which appear to be acceptable to it.

Greater Transparency. The U.S. could be more transparent about its plans for the future development of its missile defense systems in order to address Russian concerns about the open-ended nature of its missile defense program. However, the U.S. missile defense program is not building towards a planned objective final system, but is structured to evolve over time. Moreover, to the extent to which longer-term information about plans for the system were available, Russia might find them more frightening than reassuring. Finally, the current Congress has made it very clear that it will not allow the Missile Defense Agency to share any classified information with Russia.

Conclusions

Although Russian statements frequently lump together CPGS weapons and BMD systems as threats, they actually may have quite different implications for Russian strategic nuclear forces and for future prospects for reductions in U.S. and Russian nuclear forces. This should not be surprising. CPGS weapons can be thought of as being complimentary or supplementary to strategic nuclear forces, while strategic-capable BMD systems are a direct challenge to them.

The retaliatory capability of current Russian strategic nuclear forces is entirely due to their ability to avoid being located accurately enough to be attacked (with the dangerous exception of missiles that could be launched on warning of attack). CPGS weapons will not change this situation. Moreover, Russian retaliatory capabilities may be improving as its ICBM force grows increasingly mobile and its submarine-based missile forces is modernized.

In principle, Russian reductions well below the New START level of about 1,500 ICBM and SLBM warheads in the face of U.S. CPGS deployments should then be possible, because these reductions can be accomplished solely by reducing the number of warheads on these missiles, without decreasing the number of missiles which would have to be attacked to disarm Russia.

The deployment of CPGS weapons raises some dangers involving nuclear weapons. An attack using some types of CPGS weapons could be mistaken as a preemptive nuclear attack, leading to an unintentional nuclear war. Attacks by CPGS weapons on military infrastructure that supports both conventional and nuclear forces, such as airbases and command and control facilities, or on dual-purpose conventional/nuclear weapons, could help escalate a conventional war into a nuclear war. To the extent possible, future deployments of CPGS weapons should designed to minimize these risks.

However, a greater concern for a Russian planner could well be that the United States might attempt to use CPGS weapons to attack some of the non-survivable parts of its nuclear forces, such as silo-based ICBMS or early warning radars. More generally, if Russia perceives the United States as gaining a significant military advantage through CPGS deployments, it might attempt to compensate by increasing its emphasis on nuclear forces and thereby be less willing to agree to reduce the size of its nuclear forces. The possible U.S. deployment of conventional sea-based intermediate-range boost-glide weapons appears to be the greatest near- to medium-term problem in this regard. It may be unrealistic to expect Russia to agree to further reductions in its nuclear arsenal if the U.S. proceeds to deploy significant numbers of such weapons, over Russian objections and without any limitations or verification.

Large-scale deployments of strategic-capable BMD systems pose a more direct threat to possible deep cuts in nuclear weapons. They are fundamentally incompatible with deep nuclear reductions, at least as long as nations continue to rely on nuclear-armed ballistic missiles as their primary (or only) nuclear deterrent. This has been recognized for a long time, but has not yet strongly influenced offensive force deployments because defense deployments have so far been far too small to pose a threat to already existing large nuclear ballistic missile forces.

The situation now (or in 2018, when New START goes into effect) where each side has roughly 1,500 ballistic missile warheads and fewer than 100 strategic-capable BMD interceptors is clearly both arms race and crisis stable. Although the United States is expanding its strategic-capable BMD capabilities, it is not doing so in response to Russian forces.

On the other hand, a future world in which the United States and Russia have deeply cut their strategic nuclear missile forces and the U.S. has a global strategic-capable BMD system with more interceptors than Russia has survivable ballistic missile warheads would clearly be both arms race and crisis unstable, unless the way Russia thinks about the role of its strategic ballistic missile forces changes dramatically. The only question is at what level of Russian forces relative to U.S. BMD deployments would this situation become unacceptable to Russia.

If the U.S. and Russia cooperatively sought to reduce their reliance on nuclear armed ballistic missiles, it might be possible to do so over time. However, the time in which to do so is running short. The United States' plans for future BMD deployments are proceeding without taking Russia's concerns into account. In fifteen to twenty years, the United States plans to have in place a globally (northern hemisphere, at least) integrated BMD system with hundreds of strategic-capable interceptors, with this number growing steadily each year. 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 neither country appears to be even remotely interested in such a change of thinking.

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 Russia 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. While Russia could take other steps to preserve the effectiveness of its nuclear forces, such as deploying countermeasures, putting forces on higher alert levels, or planning to attack the defenses, the surest and most certain response is to expand, or at least not further reduce, these missiles forces. Achieving deep reductions, even just to a level that allows other countries to be brought in, will then be if not impossible, vastly more difficult.