Putin and Missile Defense Malaise

Broadening US Options

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Introduction

On 1 March 2018, President Vladimir Putin promised a new generation of Russian nuclear weapons specifically intended to circumvent US strategic missile defenses.[1] The weapons mentioned in Putin's presentation to the Federal Assembly included an intercontinental cruise missile, a hypersonic glide weapon, and a long-range nuclear torpedo, in addition to other nuclear-capable delivery systems in development and/or deployment. One of the reasons for Russo–American and NATO–Russian divergence on missile defenses is the Russian concern that NATO regional and US global missile defenses could overturn the stability of nuclear deterrence based on assured retaliation.[2] Although Moscow's concerns are understandable, given Russia's dependence on nuclear weapons to deter or stop a feared invasion from the West, US planning assumes that advanced ballistic missile defenses in Europe exist to protect NATO allies from small-scale attacks from Iran—not Russia.[3]

On the other hand, missile defenses can be tasked to protect retaliatory forces as their priority, or singular, mission. For example, terminal antimissile defenses for intercontinental ballistic missiles (ICBM), deployed in missile silos, could be designed to protect those retaliatory forces from first strikes instead of populations from retaliatory attacks. The possibility of defending silo-based ICBMs with terminal ballistic missile defenses (BMD) to reduce their first-strike vulnerability was studied during the Cold War and subsequently by the US government and various defense contractors.[4] The Nixon administration approved deployment of the Sentinel-Safeguard system, with a primary mission of defending retaliatory forces, in 1969, but the United States subsequently mothballed the system after agreeing to the Anti-Ballistic Missile (ABM) Treaty in 1972.[5]

In the sections that follow, we first consider some of the military-strategic and arms control issues that have complicated US– and NATO–Russian dialogue on missile defenses. In the second section, we analyze the hypothetical impacts that ICBM silo defenses deployed by the United States and Russia might have on deterrence and arms control stability, including consideration of possible alternatives.[6] The development and eventual deployment by Russia and the United States of advanced hypersonic weapons make this topic especially timely. Hypersonics could pose time-urgent threats to both fixed and mobile strategic launchers, but especially to silo-based ICBMs.[7]

Post–Cold War and Missile Defenses

The United States and Russia now field 80 percent fewer operationally deployed strategic nuclear weapons than during the Cold War. As table 1 illustrates, the United States and Russia each field a force with a slightly different mix of warheads and delivery vehicles—all of which meet the requirements of the New Strategic Arms Reduction Treaty (START).

Table 1. New START Treaty aggregate numbers of strategic offensive arms

Category of Data	United States	Russia
Deployed ICBMs, deployed SLBMs, and deployed heavy bombers	656	524
Warheads on deployed ICBMs, on deployed SLBMs, and nuclear warheads counted for deployed heavy bombers*	1,365	1,461
Deployed and non-deployed Launchers of ICBMs, deployed and non-deployed launchers of SLBMs, and deployed and non-deployed heavy bombers	800	760

*Under New START counting rules, each bomber counts as one warhead.
Source: US Department of State, *New START Treaty Aggregate Numbers of Strategic Offensive Arms* (Washington, DC: US Department of State, 2019).

At the same time the number of operationally deployed strategic nuclear weapons was in dramatic decline, the United States refused efforts on the development of antiballistic missile defenses.[8] Antiballistic missile defense technologies are of interest not only to the United States and Russia but also to other states who feel threatened by the spread of ballistic missiles outside of Europe. The spread of ballistic missiles and the decline of nuclear arsenals occurred independently but ultimately converged in their significant impact on strategic stability. One example is prescient. Japan, a nonnuclear state, would prefer neither to join the ranks of nuclear weapons states nor to enter into a regional nuclear arms race. It is, however, very interested in antimissile defenses as a defense against a limited nuclear strike—possibly from North Korea. Japan is already cooperating with the United States in developing and deploying theater missile defenses for its state territory and contiguous waters.[9] This stance is not unreasonable from Japan's perspective, considering its proximity to North Korea, China, and other Asian nuclear powers. Missile defenses might provide for a country like Japan or South Korea an alternative "deterrent by denial" instead of a nuclear deterrent by threat of unacceptable second-strike retaliation.[10] Antiballistic missile defenses could also serve as an insurance policy against accidental launches or unauthorized rogue attacks.

Table 2 summarizes active and planned phases of the US–NATO European Phased Adaptive Approach (EPAA) missile defense plan, which could be replicated in Japan, Korea, or elsewhere.

Table 2. European Phased Adaptive Approach to missile defense*

	Phase I	Phase II	Phase III	Phase IV (canceled March 2013)
Timeframe	2011	2015	2018	2020
Capability	Deploying today's capability	Enhancing medium-range missile defense	Enhancing intermediate-range missile defense	Early intercept of MRBMs, IRBMs and ICBMs
Threat/Mission	Address regional ballistic missile threats to Europe and deployed U.S. personnel	Expand defended area against short- and medium-range missile threats to Southern Europe	Counter short-, medium-and intermediate-range missile threats to include all of Europe	Cope with MRBMs, IRBMs, and potential future ICBM threats to the United States
Components	AN/TPY-2 (FBM) in Kurecik, Turkey; C2BMC in Ramstein, Germany; Aegis BMD ships with SM-3 IA off the coast of Spain	AN/TPY-2 (FBM) in Kurecik, Turkey; C2BMC in Ramstein, Germany; Aegis BMD ships with SM-3 IB off the coast of Spain; Aegis Ashore with SM-3 1B in Romania	AN/TPY-2 (FBM) in Kurecik, Turkey; C2BMC in Ramstein, Germany; Aegis BMD ships with SM-3 IIA off the coast of Spain; Aegis Ashore With SM-3 IIA in Romania and Poland	AN/TPY-2 (FBM) in Kurecik, Turkey; C2BMC in Ramstein, Germany; Aegis BMD ships with SM-3 IIA off the coast of Spain; Aegis Ashore With SM-3 IIB in Romania and Poland
Technology	Exists	In testing	Under development	In conceptual stage when canceled
Locations	Turkey, Germany, ships off the coast of Spain	Turkey, Germany, ships off the coast of Spain, ashore in Romania	Turkey, Germany, ships off the coast of Spain, ashore in Romania and Poland	Turkey, Germany, ships off the coast of Spain, ashore in Romania and Poland

*Separate national contributions to the mission of European BMD have been announced by Netherlands and France.

Source: Karen Kaya, "NATO Missile Defense and the View from the Front Line," *Joint Force Quarterly*, 71, no. 4 (2013), 84-89.

Key:
Aegis Ashore = land-based component of the Aegis BMD system;
AN/TPY-2 (FBM) = Army Navy/Transportable Radar Surveillance, Model 2 (Forward-based Mode)
BMD = ballistic missile defense
C2BMC = command, control, battle management, and communications
ICBM = intercontinental ballistic missile
IRBM = intermediate-range ballistic missile
MRBM = medium-range ballistic missile

The Obama administration's attempt to "reset" relations with Russia led to the conclusion of the New START agreement and to a temporary thaw in US–Russia and Russia–NATO relations on the issue of missile defenses.[11] However, the thaw was temporary, as animosity over missile defenses returned in 2011–2012 when the Obama administration missile defense plan for Europe became clearer and its implications for Russia became a presidential election issue.[12]

To appease the Russians, then–US Secretary of Defense Chuck Hagel announced in 2013 that the Pentagon would cancel plans for the fourth phase of EPAA, regarded as the phase most objectionable to Russia, which viewed the system as a way to undermine Russian nuclear deterrence. Neither President Putin nor his military leadership was mollified by this US decision.[13] Moscow continued to demand either a change in the US plan or a Russian level of involvement and participation in designing the European BMD system that would satisfy Russia's nervous military leaders and politicians as to American and NATO intentions and capabilities.[14]

(Image courtesy of news2.ru)

Figure 1. Russia resurgent. As President Putin strives to rebuild Russia's international standing, Moscow has become increasingly adversarial toward the West.

Russian leaders persist in indicating that, if dissatisfied with respect to European missile defenses, they will decline further cooperation in offensive nuclear arms reductions and possibly deploy missiles capable of launching nonstrategic nuclear weapons closer to Russia's borders with NATO.[15] In addition, the United States and Russia suspended their commitments to maintaining the Intermediate Nuclear Forces (INF) Treaty in 2019, and one of Russia's arguments for doing so was its insistence that US antimissile system (Aegis ashore) deployments in Romania and prospectively Poland could also be used for launching offensive missiles of medium or intermediate ranges.[16]

Russia is especially sensitive to NATO's reach into former Soviet and "near-abroad" states and security space, within which Russia claims privileged interests.[17] These sensitivities to NATO visibility in post-Soviet space bordering Russia extend to any plans for NATO land-based interceptors, radars, or other components of a European missile defense plan. Proximity assists with the accuracy of antiballistic missile defenses, so it should come as no surprise that, despite American assurances, Russia is deeply concerned about the placement of such systems in former Warsaw Pact nations.

Methodology

The probable performance of antiballistic missile defenses against offensive second-strike retaliation is unknown due to the uncertainties of current and future ballistic missile defense technologies.[18] Nevertheless, it seems reasonable to assume that the larger the offensive retaliatory force the more challenging the problem is for the defense. In addition, missile defenses to protect populations, as opposed to retaliatory forces or other "hard" targets, are incredibly demanding because the arithmetic greatly favors the attacker.[19] Even a small number of warheads penetrating a defense and aimed at population centers could create historically unprecedented destruction.

Thus, defenses of population centers have to be perfect or nearly perfect to be appealing to scientists or to deterrence theorists—but not necessarily to governments. Governments might reason that even imperfect defenses complicate the prospective first striker's attack plans, at least at the margin, and that in a crisis any hesitancy works in favor of the defender. This reasoning might be more compelling if defenses were deployed to protect retaliatory forces instead of populations. The formidable challenge facing population defenses against large-scale missile attacks has been shown in a number of analyses. For example, one study estimated the numbers of US direct, short-term casualties and collateral damage to medical facilities from various Russian nuclear attacks in 2002.[20] In one scenario, a Russian attack against US population targets using 500 weapons of 550kt each is opposed by US antimissile defenses of variable capability. The Russian targeting plan is deliberately structured to maximize US population losses, and 25 percent of the Russian warheads are assumed to malfunction. US missile defense intercept capabilities range from 0 percent to 30 percent of the attacking warheads. Summary results include those shown in table 3, as below.

Table 3. Estimated Casualties: 500 Warhead Attack on Population Centers, US Missile Defenses

Percent of incoming warheads intercepted	Total number of exploding warheads	Mean number of deaths in mass fire zones (thousands)
0%	375	97,104 plus or minus 2,714
10%	338	87,394 plus or minus 2,568
20%	300	77,683 plus or minus 3,061
30%	262	67,973 plus or minus 3,180

Source: Ira Helfand,MD; Lachlan Forrow, MD; Michael McCally,MD, PhD; and Robert K. Musil, MPH, PhD, "Projected US Casualties and Destruction of US Medical Services from Attacks by Russian Nuclear Forces," *Medicine and Global Survival* 7, no. 2 (February 2002): 68–76, excerpted from table 3, p. 73.

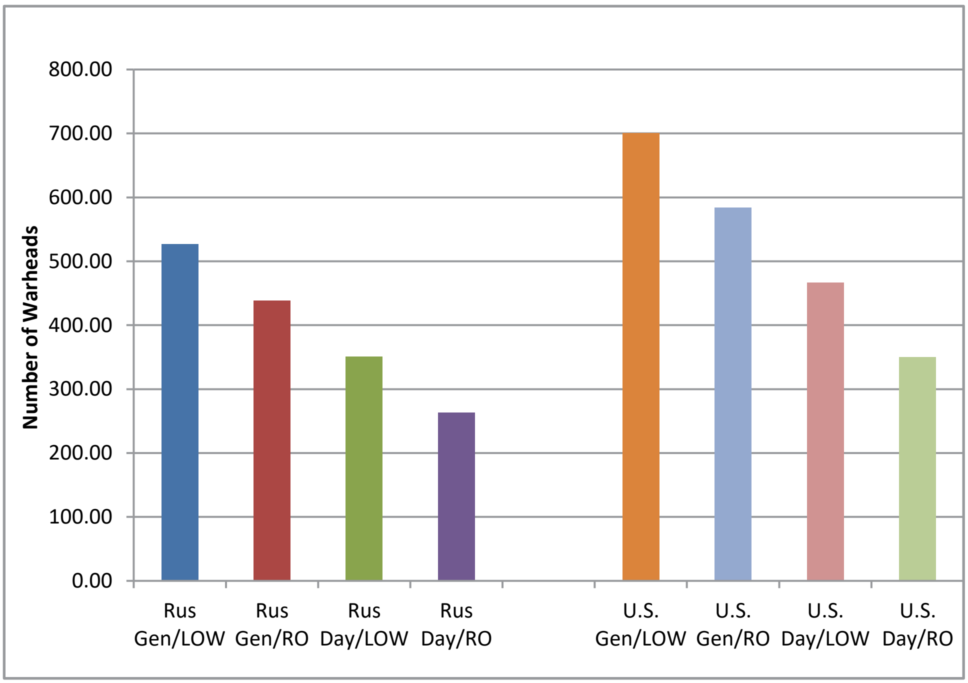
If the task of defending populations against large-scale attacks seems hopeless, a cost-effective alternative would be the fielding of antiballistic missile defenses for the United States' retaliatory forces. Given the current level of technology, such a system would have a sufficient kill probability that an attacker—Russia—would be required to dramatically increase the number of ICBMs used in a first strike, potentially making such a strike untenable. With missile defenses for US retaliatory forces intended to dilute an attacker's first strike, not its retaliatory second strike, such systems could not face the same criticism as EPAA currently faces. Therefore, Russia's complaint, that US or NATO missile defenses are really intended to deter Russia and not Iran would be less credible on that point. Of course, the United States and NATO might still want to deploy some version of EPAA against Iran or other states to the south of Europe, but they could do so more unambiguously without provoking Russian concerns about nullification of Russia's deterrent.

As mentioned above, the primary advantage of using missile defenses for retaliatory forces instead of cities is that the arithmetic is much more favorable to the defender, compared to the case of population defenses. The defense of missile silos against first strikes, for example, need not perform perfectly to exert meaningful attrition against an attack. Even so-called simple-novel ground-based antiballistic missile defenses or other available technologies could conceivably raise the "attack price" for destroying a silo from two to four warheads (or more), depending on accuracy and yield of an attacker's weapons.[21] If, for example, the United States deploys 400 Minuteman III ICBMs, a Russian first strike, for example, will likely include a salvo of between 800 and 900 warheads devoted to ICBM launch facilities and launch control centers.[22] While this was not an impossible challenge for the Soviet Union during the Cold War, it certainly presents a significant challenge for Russia under New START. This problem is potentially insurmountable if antiballistic missile defenses are fielded to protect American ICBM fields.

Data Analysis

Would American or Russian ICBM defenses that incrementally raised the attack price against ICBM silos provide additional security worthy of the investment? In charts 1–3, we summarize the results of nuclear force exchanges between Russian and American strategic nuclear forces at prewar maximum deployment levels of 1,550, 1,000, and 500 warheads for each state. In charts 4–6, we simulate the outcomes of nuclear exchanges at maximum warhead deployment levels of 1,550, 1,000, and 500 for the United States and for Russia, each having deployed ICBM defenses that increase the survivability of silo-based missiles compared to the "no defenses" condition.[23]

Chart 1. US–Russia: Surviving and Retaliating Warheads, 1,550 Deployment Limit



Key:

Gen/LOW = Generated Alert/Launch on Warning

Gen/RO = Generated Alert/Riding Out the Attack

Day/LOW = Day-to-Day Alert/Launch on Warning

Day/RO = Day-to-Day Alert/Riding Out the Attack

Chart 2. US–Russia: Surviving and Retaliating Warheads, 1,000 Deployment Limit

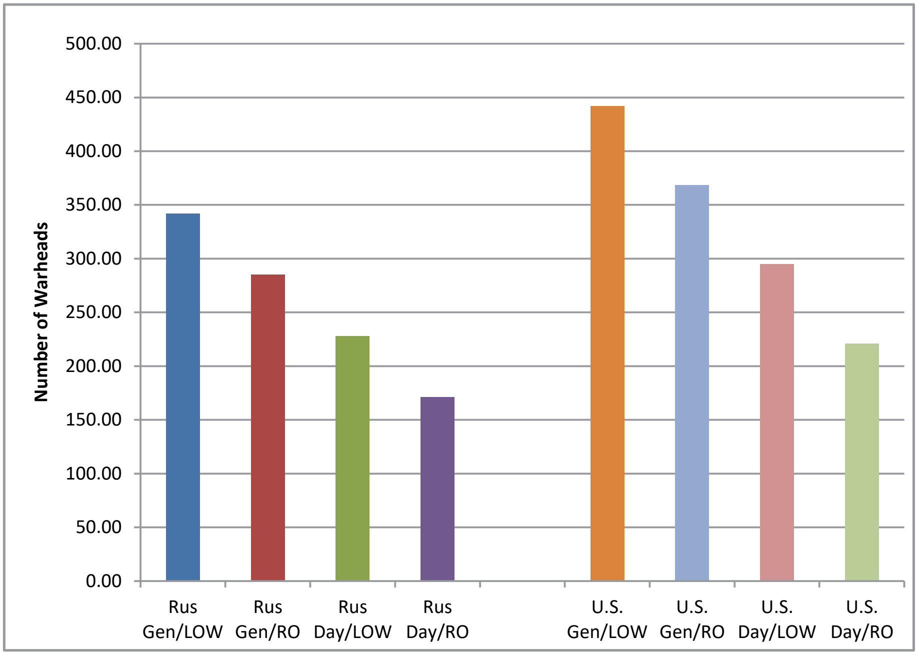


Chart 3. US–Russia: Surviving and Retaliating Warheads, 500 Deployment Limit

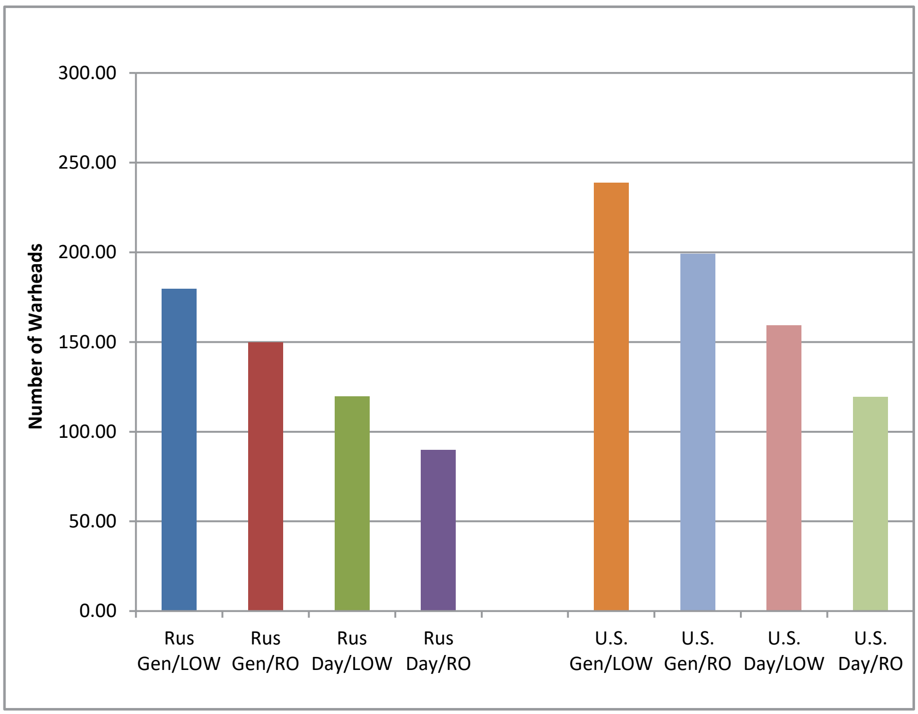


Chart 4. US–Russia: Surviving and Retaliating Warheads, 1,550 Deployment Limit, ICBM Defenses

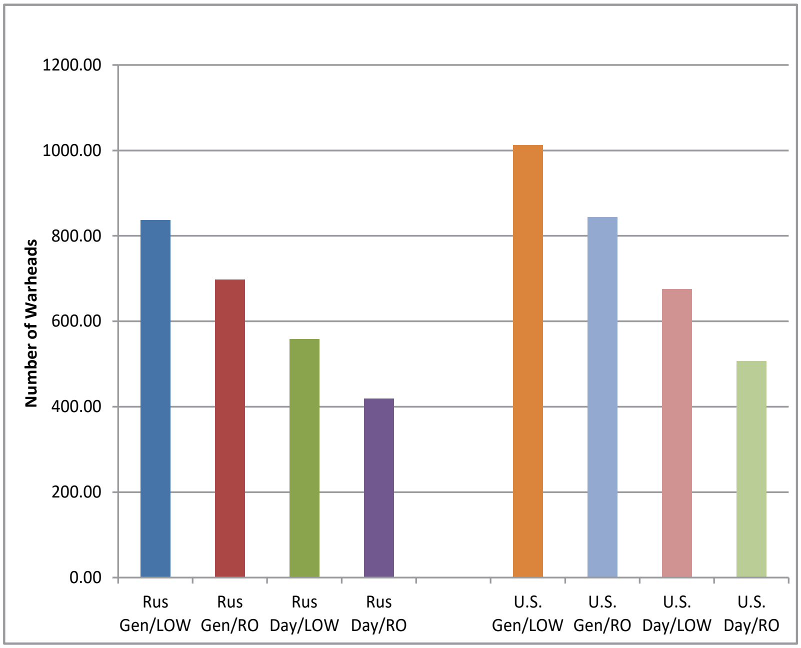


Chart 5. US–Russia: Surviving and Retaliating Warheads, 1,000 Deployment Limit, ICBM Defenses

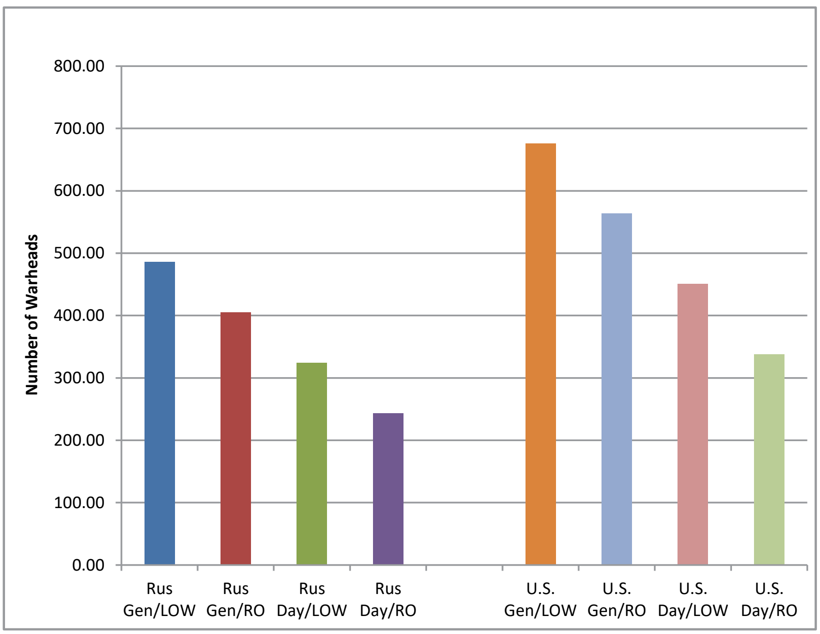
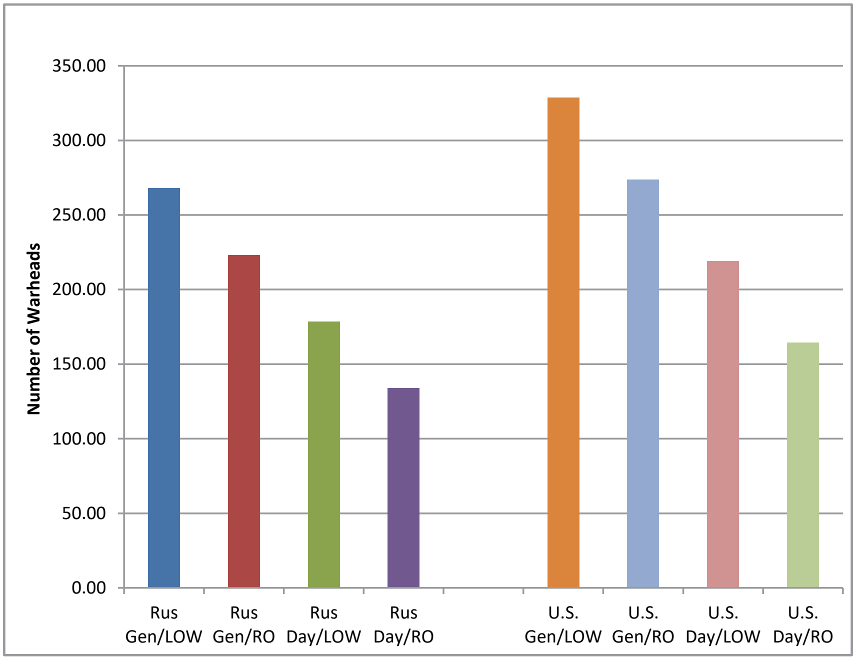


Chart 6. US–Russia: Surviving and Retaliating Warheads, 500 Deployment Limit, ICBM Defenses



The results summarized in charts 1–6 show that silo defenses could increase the percentage of surviving and retaliating ICBM warheads, relative to the undefended condition. The question is whether the improvement in outcomes for ICBM survivors is meaningful in terms of strategy. The picture is mixed. On one hand, the overall numbers of US and Russian ICBMs that survive a first strike and are available for retaliation increase, compared to the undefended condition; however, this does not change the basic structure of assured retaliation. With or without ICBM antiballistic missile defenses, the United States and Russia can guarantee adequate numbers of surviving and retaliating weapons (bomber or ballistic missile submarine delivered) to destroy any attacker as a modern society. Of course, this becomes more challenging as operationally deployed strategic weapons decline from 1,550 to 1,000, or even 500 weapons.

It might be supposed that Russia, because of its greater relative dependency on ICBMs as opposed to submarine-launched ballistic missiles (SLBM), gains relatively more than the United States does under the assumption of technologically symmetrical silo-defense deployments. However, Russian and US ICBM basing are not symmetrical. All American ICBMs are silo-based and in launch facilities that have not been hardened to account for the increasing accuracy of Russian ICBMs, while Russia's silo-based ICBMs are in launch facilities that were hardened.[24] A number of Russian ICBMs are also mobile land-based missiles. In our analysis for this study, no defenses were added for Russian mobile ICBMs, only for Russian ICBMs that are silo-based.

Upsides and Downsides: Risks and Benefits

Regardless of these considerations, from a military and deterrence standpoint, there are two potential benefits the deployment of antiballistic missile defenses provide the ICBM force and deterrence—compared to the undefended condition. First, an attacker cannot know the exact performance of antiballistic missile defenses under crisis or wartime conditions; even the defender will be estimating success based on tests and simulations. These unknown parameters of missile defense performance "under fire" will complicate an attacker's first-strike confidence. Second, the availability of silo defenses can allow leaders to feel less pressure to "use them or lose them" and increase confidence against a decision to strike preemptively. Opponents of antiballistic missile defense systems argue that current ABM technology does not perform particularly well, is too costly, and will always be overwhelmed by greater offensive weapons.[25] In many respects, these critiques are true but irrelevant. Antiballistic missile defenses, even mediocre ones, change the calculus for attacking ICBM fields and ensure that a portion of ICBMs are available for countervalue strikes. ABM systems need not be perfect. Mediocre is good enough.

Apart from these pros and cons for deterrence and nuclear crisis stability, there is also the issue of arms race stability. US antiballistic missile defenses for ICBMs might provoke Russian or Chinese countermeasures in the form of their own missile defenses or offsetting modernization of offenses. Russian or Chinese ICBM defenses might have a similar effect on the United States. But in all cases, ICBM silo defenses would not be a threat to the second-strike capability of another state. Thus, the potential for creating stability is a net positive.

Regardless of US strategic nuclear force size, the strategic logic for deploying available missile defense technologies to defend the ICBM force, and encourage Russia to do the same, is overwhelming. Since Russia is even more dependent on ICBMs as a makeweight of its strategic nuclear forces, the fielding of antiballistic missile systems is a logical proposition. As mentioned, there are drawbacks to these systems that leave decision makers in a number of advanced nations uninterested in their development.

First, for a cash-strapped country like Russia, antiballistic missile systems are expensive. Developing the scientific and industrial infrastructure to build and field such systems is a challenge for any nation.[26] While a nation like Iran can build a ballistic missile, building a missile that can hit another missile in flight is a completely different proposition. Another issue for antiballistic missile defenses is that two of the three components of the US nuclear triad, submarines and bombers, are presumptively survivable without missile defenses, provided (especially in the case of bombers) sufficient warning is available.

A final reason for lack of interest in missile defenses for ICBMs is more controversial from an arms control perspective. ICBMs are the quick reaction component of the US and Russian nuclear triads. Although SLBMs can also be tasked for prompt launch missions, their uniqueness lies in their unmatched survivability. ICBMs also do not have to move to another location before firing after receiving duly authorized launch commands, as ballistic missile submarines do. It is also worth noting that although the command, control, and communications (C3) systems for ballistic missile submarines are reportedly as reliable as those for strategic land-based missiles, the latter are not quite as complicated.[27]

On the other hand, some arms control experts maintain that the United States and Russia maintain too many ICBM warheads on ready alert for prompt launch, creating a "hair trigger" problem during a prospective nuclear crisis.[28] And other arms control experts argue that the Cold War history of strategic missile defenses, whether deployed by the United States or by the Soviet Union, was that they generated offsetting changes in the other side's force modernization and nuclear targeting plans, including specific plans for the suppression of missile defenses.[29]

Conclusion

It is beyond the scope of this study to survey all candidate missile defense technologies or missions. Its focus is on the question of whether Russo–American disagreements about missile defenses could be partially mitigated by the substitution of unambiguously "defensive" BMD deployments for those capable of second-strike nullification.[30] Missile defenses remain debatable as technological game changers for the stability of strategic nuclear deterrence as between the United States and Russia. One complication is that, as Keith B. Payne has warned, the very concept of nuclear-strategic "stability" is more ambiguous and contestable than it was during the Cold War years:

> In the contemporary era, there can be no generally-applicable "rule of thumb" derived from the US-Soviet experience for predicting that a particular set of US capabilities will be "stabilizing" or "destabilizing" across a spectrum of potential adversaries and contexts. In some cases, for example, rather than being a cause of deterrence "instability" as envisaged in the Cold War construct, US BMD capabilities able to defeat an adversary's prospective missile attack may well be key to denying the political or military value that would underlie an adversary's decision to attack, i.e., missile defense in such a case would rightly be deemed "stabilizing."[31]

On the other hand, US current and proposed missile defenses in Europe have already contributed to friction with Russia over security issues, including the stability of mutual deterrence based on assured second-strike retaliation. The preceding analysis suggests that, all things being equal, deploying missile defenses tasked uniquely for the protection of retaliatory forces instead of populations could reduce first-strike vulnerability for US and Russian silo-based ICBMs, increasing their confidence in assured retaliation. On the other hand, the two states could reduce ICBM vulnerability by other means, including the replacement of silo-based ICBMs by mobile missiles.[32] Decision makers would obviously have to take into account the cost factors in protecting ICBM silos with BMD, compared to other options, including a shift from silo to mobile ICBM basing.[33]

Some in the arms control community would solve the issue of ICBM basing by moving to a dyad of US strategic nuclear retaliatory forces, eliminating ICBMs. Others have proposed that the United States rely on a strategic nuclear "monad" of SLBMs. In either case, eliminating one or two legs of the US triad, advocates of such a move suggest conventionally armed missiles and/or bombers could be substituted for nuclear-armed delivery systems of the same type. From the standpoint of stable deterrence and nuclear arms control, however, elimination of one or more arms of the nuclear triad is not necessarily a "plus." In fact, the opposite may be the case. As Russian and American strategic nuclear arsenals are reduced in size, the diversity of the triad becomes more, not less, important for survivability and, therefore, for stability.[34]

From a more inclusive perspective, symmetrical nuclear arms reductions, as between the United States and Russia, may no longer have symmetrical effects, as assumed to be the case during the Cold War. According to Keith Darden and Timofei Bordachev, the United States and Russia should seek not only strategic stability based on mutual deterrence but also strategic compatibility, allowing for differing but compatible security portfolios.[35] The objective would be to disconnect arms control from an exclusive reliance on parity and symmetry as indicators of security and stability.[36] Stability through compatibility, instead of symmetry and parity in forces and deployments, is certainly one option that policy makers will need to consider in a complicated twenty-first century.

Although we did not discuss the issue here, technological developments are also set to dramatically change the dynamic of nuclear deterrence. New low-observable cruise missiles and hypersonic glide vehicles that can strike with little or no warning, for example, may upend our strategic planning calculus, as the United States seeks to find new ways to either address or circumvent these and other capabilities.[37] Whatever the future may hold for nuclear forces, the need to ensure their survivability is becoming increasingly complex and deserving of considerable discussion.

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Notes

1. Vladimir Putin, *Presidential Address to the Federal Assembly* (speech, 1 March 2018). *See also* Neil MacFarquhar and David E. Sanger, "Putin's 'Invincible' Missile Is Aimed at U.S. Vulnerabilities," *New York Times*, 1 March 2018; Dave Majumdar, "Russia's Nuclear Weapons Buildup is Aimed at Beating U.S. Missile Defenses," *National Interest*, 1 March 2018; Paul Sonne, "Pentagon Looks to Adjust Missile Defense Policy to Include Threats from Russia, China," *Washington Post*, 2 March 2018); and Eric Gomez, "Why Putin Is Obsessed with America's Missile Defenses," *National Interest*, 3 March 3, 2018.

2. For background on this issue, *see* Andrew Futter, *Ballistic Missile Defence and US National Security Policy: Normalisation and Acceptance after the Cold War* (London: Routledge, 2013); and Keir Giles and Andrew Monaghan, *European Missile Defense and Russia* (Carlisle, PA: Strategic Studies Institute, US Army War College Press, 2014), 28.

3. Russia's 2014 Military Doctrine, signed into law by President Vladimir Putin on 26 December 2014, reportedly identifies NATO's increasing military potential as among the most important external threats to Russia and notes Russia's specific concern about NATO plans for a global antiballistic missile system. *See* Yuri Smityuk, "Putin Endorses Updated Version of Russia's Military Doctrine," *ITAR-TASS*, 26 December 2014. *See also* Roger McDermott, "Putin Signs New Military Doctrine: Core Elements Examined," *Jamestown Foundation Eurasia Daily Monitor*, 6 January 6, 2015.

4. Lauren Caston, Robert S. Leonard, Christopher A. Mouton, Chad J.R. Ohlandt, S. Craig Moore, Raymond E. Conley, and Glenn Buchan, *The Future of the U.S. Intercontinental Ballistic Missile Force* (Santa Monica, CA: RAND Corporation, 2014), 21–47.

5. The Sentinel-Safeguard system included two kinds of missile interceptors: Spartan missiles for interception outside of the atmosphere, and shorter-range Sprint missiles for endo-atmospheric intercept. Both missiles carried nuclear warheads. Originally proposed as a limited defense of cities against a Chinese or other light attack, its mission profile was reprioritized for the protection

of ICBM fields in North Dakota and Montana. See *Department of the Army Historical Summary, FY 1969* (Washington, DC: US Army Center for Military History, 1973), 31–33, 89–90.

6. In this study, we assume that ICBM silo defenses would be terminal defenses tasked for endo-atmospheric intercept instead of mid-course defenses of the kind now deployed in the US ground-based mid-course defense (GMD) program and designed for exo-atmospheric intercept. In addition, new technologies for boost phase intercept of ballistic missiles in their earliest stages of powered flight would, if successful, also protect retaliatory forces in addition to populations and other targets. On the other hand, projected US strategic nuclear modernization programs might replace silo-based ICBMs with mobile versions in the Ground Based Strategic Deterrent, making silo defenses unnecessary.

7. *See* Dawn Stover, "What Would Russia Nuke?," *Bulletin of the Atomic Scientists* (March 2019); and John A. Tirpak, "Roper: Hypersonics Capability Less Than Two Years Away" *Air Force Magazine* (February 2019).

8. 8 Kingston Reif, *Current U.S. Missile Defense Programs at a Glance* (Washington, DC: Arms Control Association, 2019).

9. Thomas Karako, *Shield of the Pacific: Japan as a Giant Aegis Destroyer*" Center for Strategic and International Studies (Washington, DC: 2018).

10. Choe Sang-Hun, "South Korea Tells China Not to Meddle in Its Missile-Defense Talks With U.S.," *New York Times*, 25 February 2016, A6. *See also* Kim Hwan Yong, "S. Korea Eyes US Missile Defense System as North Continues Tests," *Voice of America*, 29 January 2016.

11. *Treaty between the United States of America and the Russian Federation on Measures for the Further Reduction and Limitation of Strategic Offensive Arms* (Washington, DC: US Department of State, 8 April 2010).

12. *See* Karen Kaya, "NATO Missile Defense and the View from the Front Line," *Joint Force Quarterly* 71, no. 4 (2013): 84–89. *See also* Association of the US Army, *U.S. Army Integrated Air and Missile Defense Capabilities: Enabling Joint Force 2020 and Beyond* (Washington, DC: Institute of Land Warfare, 2014); Steven J. Whitmore and John R. Deni, *NATO Missile Defense and the European Phased Adaptive Approach: The Implications of Burden Sharing and the Underappreciated Role of the U.S. Army* (Carlisle, PA: Strategic Studies Institute, US Army War College, 2013); Patrick J. O'Reilly, *Ballistic Missile Defense Overview*, (Washington, DC: US Department of Defense, 2012); and North Atlantic Treaty Organization, *NATO Ballistic Missile Defense (BMD) Fact Sheet* (Brussels: North Atlantic Treaty Organization, 2012).

13. Gordon Lubold and Julian E. Barnes, "U.S. Dismisses Putin's Objection to European Missile Systems," *Wall Street Journal*, 14 May 2016. *See also* "U.S. Activates Romanian Missile Defense Site, Angering Russia," *Reuters*, 12 May 2016.

14. "Target for U.S. Missile Shield in Europe Still Important Issue, Russia Sees It as Threat–Kremlin Spokesman," *Interfax*, 12 May 2016. Some experts contend that, even as Russia denounces US and NATO missile defenses, Russia is developing its own unified "aerospace defense" system, including capabilities for intercepting US ballistic missiles. *See* Mark B. Schneider and Peter Huessy, "Russian Deployment of Missile Defenses: Hidden in Plain Sight," Gatestone Institute, 18 February 2013.

15. Examples include "Putin: Russia Will Consider Tackling NATO Missile Defense Threat," *RT*, 13 May 2016; "Federation Council Not Ruling Out Deployment of US Missile Defense Shield in Romania May Influence New START Treaty's Fate," *Interfax*, 13 May 2016; and "Russia Could Drop START Treaty Due to New Air Defense Systems in Europe," *Sputnik*, 12 May 2016.

16. This Russian assessment was based on the assumption that the Aegis Mk-41 Vertical Launching System (VLS) is also capable of launching offensive Tomahawk sea-launched cruise missiles over ranges that would violate INF limits of 500 to 5,500 kilometers. The US government says the Mk-41 launchers deployed in Europe lack software, fire control hardware, support equipment, and other infrastructure necessary to launch Tomahawks. *See* Matt Korda and Hans M. Kristensen, "US Ballistic Missile Defenses, 2019," *Bulletin of the Atomic Scientists*, 24 October 2019, 295–306.

17. For historical perspective on this and other issues related to contemporary Russian security policy, *see* Olga Oliker, Christopher S. Chivis, Keith Crane, Olesya Tkacheva, and Scott Boston, *Russian Foreign Policy in Historical and Current Context: A Reassessment* (Santa Monica, CA: RAND Corporation, 2015) and Walter Laqueur, *Putinism: Russia and Its Future with the West* (New York: St Martin's Press, 2015). *See also* Jacob W. Kipp, "Russian Military Doctrine: Past, Present, and Future," in *Russia's Military Politics and Russia's 2010 Defense Doctrine*, ed. Stephen J. Blank (Carlisle, PA: Strategic Studies Institute, US Army War College, 2011), 63–151.

18. For an example, *see* Committee on an Assessment of Concepts and Systems for US Boost-Phase Missile Defense in Comparison to Other Alternatives, *Making Sense of Ballistic Missile Defense: An Assessment of Concepts and Systems for U.S. Boost-Phase Missile Defense in Comparison to Other Alternatives* (Washington, DC: National Academies Press, 2012). *See also* George N. Lewis and Theodore A. Postol, "A Flawed and Dangerous U.S. Missile Defense Plan," *Arms Control Today* (May 2010).

19. One reason is that attackers can use strategems, such as decoys or antisimulation, to complicate the job of defenses that depend upon intercept in the vacuum of space, including so-called midcourse intercept systems. *See* Richard L. Garwin, "A Defense that Will Not Defend," *Washington Quarterly* 23, no. 3 (Summer, 2000): 109–23.

20. Ira Helfand, Lachian Forrow, Michael McCally, and Robert K. Musil, "Projected US Casualties and Destruction of Medical Services from Attacks by Russian Nuclear Forces," *Medicine and Global Survival* 7, no. 2 (February, 2002), 68–76.

21. Ashton B. Carter, "BMD Applications: Performances and Limitations," in *Ballistic Missile Defense*, ed. Ashton B. Carter and David N. Schwartz (Washington, DC: Brookings Institution, 1984), 98-181.

22. Attacks would include launch control centers in addition to silos.

23. We employ James Scouras' Arriving Weapons Sensitivity Model (AWSM) in making calculations and drawing graphs. Additional information about the model is available in Stephen J. Cimbala and James Scouras, *A New Nuclear Century* (Westport, CT: Praeger Publishers, 2002).

24. Pavel Podvig, "The Window of Vulnerability That Wasn't: Soviet Military Buildup in the 1970s--A Research Note" *International Security* 33, no. 1 (Summer 2008): 118–38.

25. Joan Johnson-Freese and David T. Burbach, "The Best Defense Ever? Busting Myths about the Trump Administration's Missile Defense Review," *War on the Rocks*, 6 February 2019.

26. US Congressional Budget Office, *Approaches for Managing the Costs of U.S. Nuclear Forces, 2017 to 2046* (Washington, DC: Congressional Budget Office, 2017).

27. Bruce G. Blair, *Strategic Command and Control: Redefining the Nuclear Threat* (Washington, DC: Brookings Institution, 1985), Ch. 7–8.

28. James Cartwright, *Modernizing U.S. Nuclear Strategy, Force Structure and Posture*. (Washington, DC: Global Zero, May 2012).

29. Hans M. Kristensen, Matthew G. McKinzie, and Robert S. Norris, "The Protection Paradox," *Bulletin of the Atomic Scientists* (March/April 2004): 68–77.

30. For broader comparative perspective and appraisal, *see* Committee on an Assessment of Concepts and Systems for U.S. Boost-Phase Missile Defense in Comparison to Other Alternatives, *Making Sense of Ballistic Missile Defense: An Assessment of Concepts and Systems for U.S. Boost-Phase Missile Defense in Comparison to Other Alternatives* (Washington, DC: National Academies Press, 2012).

31. Keith B. Payne, "Nuclear Deterrence in a New Era: Applying 'Tailored Deterrence,'" *National Institute for Public Policy Information Series*, No. 431 (21 May 2018).

32. Mobile ICBMs were extensively studied by the United States but never deployed. For pertinent history, *see* Steven E. Pomeroy, *An Untaken Road: Strategy, Technology, and the Hidden History of America's Mobile ICBMs* (Annapolis, MD: Naval Institute Press, 2016).

33. In addition to silo and mobile basing for ICBMs, alternatives for improving ICBM survivability include deep underground basing, mobility combined with deceptive basing (e.g., the Carter administration "racetrack" basing scheme), and launch on warning as a declaratory policy. These options are not analyzed here.

34. *See* Andrew Futter and Heather Williams, "Questioning the Holy Trinity: Why the US Nuclear Triad Still Makes Sense," *Comparative Strategy* 35, no. 4 (2016): 248–56.

35. Keith Darden and Timofei Bordachev, *The Sword and the Shield: Toward U.S.-Russian Strategic Compatibility* (Cambridge, MA: Davis Center for Russian and Eurasian Studies, Harvard University, 2014).

36. Ibid., 18.

37. *See* Adam Lowther and Curtis McGiffin, "American Needs a 'Dead Hand,'" *War on the Rocks*, 19 August 2019 and Adam Lowther and Stephen Cimbala, "Future Technology and Nuclear Deterrence," *Wild Blue Yonder*, 3 February 2020, https://www.airuniversity.af.edu/Wild-Blue-Yonder/.