ANALYSIS

Without Precedent: Global Emerging Trends in Nuclear and Hypersonic Weapons

By Brian Ellison, Dennis Evans, Matthew Lytwyn and Jonathan Schwalbe

Introduction

Going back to the days immediately after the breakup of the Soviet Union, the United States has apparently made several assumptions—some more explicit than others—about the nature of the emerging world security environment. These assumptions, overly optimistic in retrospect, relate to the role of Russia, the rise and role of China, the role of nuclear weapons in the world, and the role of new categories of weapons that did not exist in 1992. First, while the United States was probably never confident that Russia would evolve into a Western-style democracy and somewhat of an ally, the current situation probably exceeds the worst-case expectations from the 1990s. Second, the United States apparently expected—for at least 20 years—that capitalism, rising living standards, integration into the world economy, and (at least since the turn of the century) the Internet and the information age would cause China to evolve in the direction of more democracy and better relations with the West. Instead, China has become more authoritarian and more hostile to the West, while evolving into a near peer in terms of gross domestic product, conventional military power, and in terms of science and advanced technology. Third, the United States has expected a gradual reduction in the role of nuclear weapons in the world and a gradual reduction in the risk of real or threatened nuclear use. These favorable trends have not emerged, and this paper discusses nuclear developments of the three countries in detail. Finally, while no one expected military technology to stand still, most observers expected that the United States would be a world leader, if not *the* world leader, in any new category of weapons that grew to assume major military importance. Again, this has not been the case, and this paper discusses one key example in detail.

Across all of these adverse trends, three items affecting the U.S. deterrence posture stand out:

- The Chinese nuclear buildup and Chinese world leadership in hypersonic weapons (to include factors such as the number of flight tests, the number of facilities and personnel involved in hypersonics research and testing, and likely deployed inventories by 2030);
- Russian nuclear modernization, expansion of Russia's inventory of nonstrategic nuclear weapons (NSNWs), amplified by Russian aggression in Ukraine, and an increase in Moscow's nuclear alert status during the Ukraine war; and

- The North Korean buildup in intercontinental ballistic missiles (ICBMs) and U.S. challenges in defending against these ICBMs without provoking undesired reactions by Russia and China.[1]

These three issues lead to vexing questions about the adequacy of U.S. programs for strategic forces, ballistic missile defense (BMD), hypersonic weapons, and defenses against hypersonic weapons.[2] These major developments might also affect long-standing assumptions in deterrence theory, arms control, and nuclear strategy.

Chinese Nuclear and Hypersonic Weapons

Chinese Weapons

As noted earlier, China has become more internally repressive and apparently more assertive about its role in the world in the last decade, contrary to most expectations from the early 1990s through the Obama Administration. The risk of Chinese aggression against Taiwan is hard to quantify but appears to be higher than at any prior point. Such aggression, if successful, would open the door to a variety of crises afterwards. Moreover, President Biden has publicly stated that the United States would intervene militarily in the event of such Chinese aggression. In other words, the risk of military conflict between the United States and China is probably at its highest level in more than 50 years. These adverse geopolitical developments emphasize the importance of increasing Chinese military power and technological prowess. China's conventional military buildup and modernization dates back many years and is well documented. Two more recent developments, however, are alarming and probably were not expected.

Until recently, the Chinese nuclear arsenal was of modest size, which apparently influenced how the U.S. government has addressed China's nuclear weapons in official documents.[3] The 2018 NPR Report devoted less than a page to Chinese nuclear forces (versus two pages for North Korea). The Defense Department's (DOD's) annual report entitled *Military and Security Developments Involving the People's Republic of China* made no mention of a major Chinese nuclear buildup in reports from the early 2000s through 2019. The 2020 report stated that China was in the initial stages of a major nuclear buildup, and the 2021 edition provided more details. The discussion here draws mainly from the 2021 edition of that report.[4]

[1] There is also a risk of nuclear proliferation to Iran and other countries, but this paper does not address that issue.

[2] U.S. Department of Defense, *2022 Nuclear Posture Review* (Washington, D.C.: Department of Defense, 2022), available at https://www.congress.gov/116/chrg/CHRG-116shrg42239/CHRG-116shrg42239.pdf.

[3] For example, see U.S. Senate, *Advancing U.S. Engagement and Countering China in the Indo–Pacific and Beyond, Hearing before the Committee on Foreign Relations* (Washington, D.C.: Government Printing Office, September 17, 2020), available at: https://www.congress.gov/116/chrg/CHRG-116shrg42239/CHRG-116shrg42239.pdf.

[4] U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China, 2021*, (Washington, D.C.: U.S. Department of Defense, 2021), available at https://media.defense.gov/2021/Nov/03/2002885874/-1/-1/0/2021-CMPR-FINAL.PDF.

Over the next decade, China aims to modernize, diversify, and expand its nuclear forces. China is also enhancing its command-and-control systems, its early warning systems, and its capacity to produce plutonium. China will likely have at least 1,000 deliverable warheads by 2030, and this number could greatly exceed 1,000 by 2035.[5] Further, China has already established a "nuclear triad" with the development of a nuclear-capable air-launched ballistic missile (ALBM) carried by the H-6N bomber and the improvement of its ground- and sea-based nuclear capabilities.

Recent developments further suggest that China intends to move to a launch-on-warning (LOW) posture for its silo-based ICBMs and is investing in improved early warning capabilities that could support this. Such a posture could increase the risk of unwarranted nuclear escalation. As noted in the 2021 edition of DOD's China report (page 93):

> The PRC has also made advances in early warning needed to support a LOW posture. China already has several ground-based large phased-array radars—similar in appearance to U.S. PAVE PAWS radars—that could support a missile early warning role. … As of 2021, the PRC has at least one early warning satellite in orbit. In 2019, Russia offered to assist China in developing a missile early warning system.

Sea-Based Systems

China has six *Jin*-class nuclear-powered ballistic missile submarines (SSBNs), with two more under construction. (China is also developing the next-generation *Tang*-class SSBN, and the lead ship is under construction.) Each *Jin*-class SSBN carries 12 JL-2 submarine-launched ballistic missiles (SLBMs). The JL-2 has an estimated range of 7,200 to 9,000 kilometers. With this range, a Chinese SSBN would have to transit a considerable distance away from China to attack the 48 contiguous states, but a Chinese SSBN could attack Hawaii from launch points close to China. Open-source articles suggest that a JL-2 can carry a megaton-class nuclear warhead or multiple warheads of lower yield.[6] China is developing the longer-range JL-3 SLBM to provide a capability for their SSBN fleet to operate more closely to China while threatening the contiguous United States. Additionally, the *Tang*-class SSBN, currently in development, will have 16 launch tubes, putting its strike capability on par with the U.S. *Columbia*-class SSBN, whose first keel was laid recently and is planned to start deploying in 2028.[7]

---

[5] Ibid., p. 90.

[6] Matthew P. Funaiole, Joseph S. Bermudez Jr., and Brian Hart, "A Glimpse of Chinese Ballistic Missile Submarines," *CSIS*, August 4, 2021, available at https://www.csis.org/analysis/glimpse-chinese-ballistic-missile-submarines.

[7] John Grady, "Keel Laid For Nuclear Ballistic Missile Submarine District of Columbia," *USNI News*, June 4, 2022, available at https://news.usni.org/2022/06/04/keel-laid-for-nuclear-ballistic-missile-submarine-district-of-columbia.

Land-Based Systems

China has approximately 100 ICBMs, including the silo-based DF-5A and DF-5B and the solid-fueled, road-mobile DF-31, DF-31A DF-31AG, and DF-41. More worrisome, China is constructing at least three new bases for silo-launched ICBMs, and this could lead to a Chinese force of several hundred ICBMs by 2030.[8] It is likely that most of the silo-based ICBMs are equipped with multiple warheads.[9] China also has both nuclear and conventional versions of the land-based DF-21 medium-range ballistic missile (MRBM) and the DF-26 intermediate-range ballistic missile (IRBM). The DF-21 can threaten Okinawa and Japan, while the DF-26 can reach Guam. Except for silo-based ICBMs, all Chinese ground-launched missiles are mobile.[10]

Airborne Systems

China unveiled the H-6N bomber in 2019. The H-6N is the first H-6 variant capable of aerial refueling, and it can carry an ALBM that probably has a nuclear variant. The huge CH-AS-X-13 ALBM is limited to external carriage, and the maximum number of missiles per bomber is probably only one under the fuselage (possibly plus smaller weapons under the wings).[11] This ALBM is expected to have a maximum range of approximately 3,000 kilometers. China is also developing the next generation H-20 stealth bomber.[12] The availability date for the H-20 is unknown.

Table 1 provides an estimate of current Chinese missile forces, excluding purely conventional air-launched weapons. The ICBM forces are purely nuclear, while the IRBMs and MRBMs have both nuclear and conventional versions. It is uncertain whether any of the short-range ballistic missiles (SRBMs) are nuclear-capable. The ground-launched cruise missiles (GLCMs) are probably conventional, but they may have enough payload volume for a nuclear warhead. Further, DOD's 2021 China report suggests that the number of Chinese weapons is likely to grow dramatically in the next decade.

To summarize, China appears intent on becoming a great nuclear power, perhaps even a peer of the United States. The United States has long counted on facing only one peer or

---

[8] U.S. ICBM bases have 150 silos per base and one of the three bases used to have 200 silos. Unless the new Chinese ICBM bases are much smaller than U.S. ICBM bases, three new bases plus the one existing base would add up to several hundred silos. The 2021 China report does not provide an exact estimate for the size of the future Chinese ICBM force.

[9] CSIS Missile Defense Project, "Missiles of China," *CSIS*, April 12, 2021, available at https://missilethreat.csis.org/country/china/.

[10] Loc cit., and, U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China, 2021*, op. cit., p. 61.

[11] H. I. Sutton, "China's New Aircraft Carrier Killer Is World's Largest Air-Launched Missile," *Naval News*, November 1, 2020, available at https://www.navalnews.com/naval-news/2020/11/chinas-new-aircraft-carrier-killer-is-worlds-largest-air-launched-missile/.

[12] Sakshi Tiwari, "Two Distinctive Models Of China's H-20 Stealth Bomber Surface Online; Experts Decode The Mysterious Images," *Eurasia Times*, August 24, 2022, https://eurasiantimes.com/two-distinctive-model-of-chinas-h-20-stealth-bomber-surfaces/.

near peer in nuclear forces. Further, the United States has probably counted on having major superiority over China in nuclear forces well into the future, if not permanently. In any conflict or crisis between the United States and China, overwhelming U.S. nuclear superiority might well serve as a disincentive for China to use, or even threaten to use, nuclear weapons. This favorable situation may be a thing of the past in another decade. Indeed, China's ability to combine its geographical proximity to potential flashpoints in Asia, a possible advantage in its asymmetry of stakes over these flashpoints, and the coercive leverage derived by more numerous and capable nuclear forces poses major deterrence and escalation management issues for the United States. At the same time, the United States now needs to contend with the implications of a Chinese nuclear force posture which could require a larger number of U.S. nuclear forces to hold at risk, thereby complicating U.S. deterrence posture vis-à-vis Russia.

Table 1. Chinese Missiles Today[13]

Type of System	Launchers	Missiles	Range (kilometers)
ICBM (some with multiple warheads)	~100	~100	7,000 to 12,000+
IRBM	80	80 to 160	>3,000
MRBM	150	150 to 450	>1,000 but less than 3,000
SRBM	250	750 to 1,500	300 to 1,000
SLBM (possibly some with multiple warheads)	72 now and 96 soon (Jin class), larger numbers with future Tang class	At least 72	At least 7,200
ALBMs	Unknown	Unknown	3,000 or less
CJ-10 GLCM*	40 to 60+	250 to 350+	At least 1,500
All types combined	>600	>2,000	Not applicable

* There is also a bomber-launched version of the CJ-10 (an air-launched cruise missile, or ALCM)

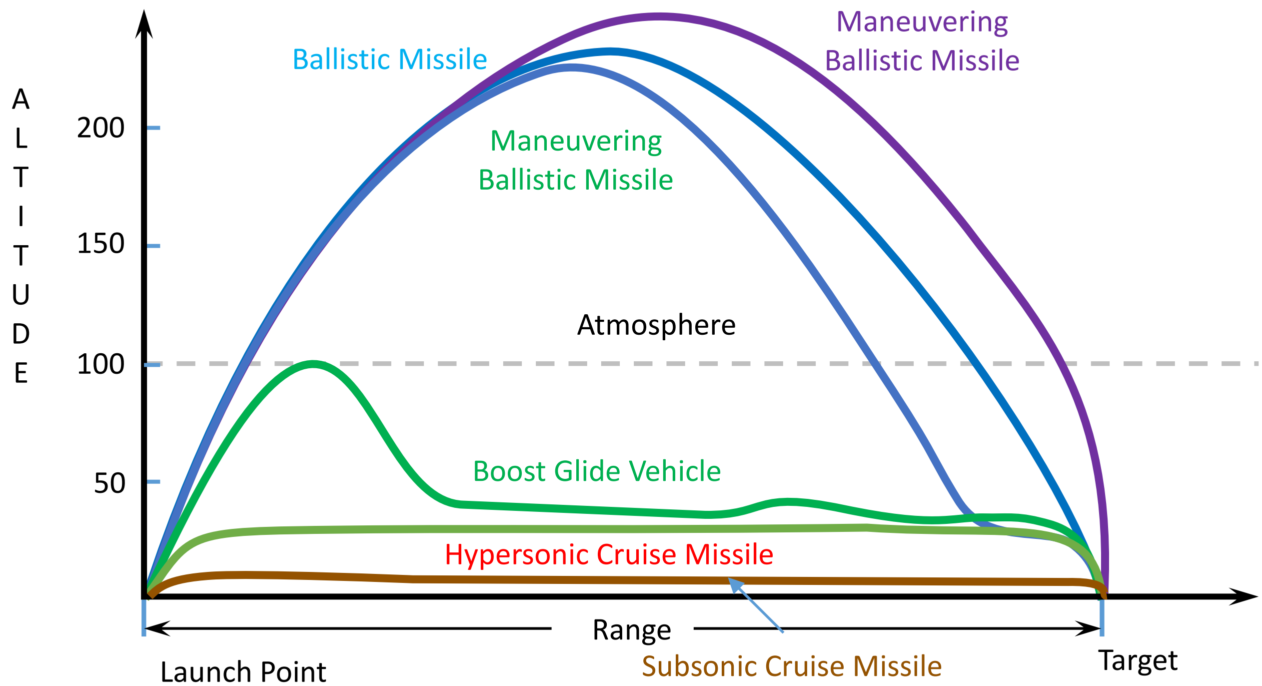
Hypersonic Missiles

China is also investing heavily in hypersonic weapons of several types (boost-glide, maneuvering ballistic missiles, and cruise missiles). A boost-glide weapon uses a rocket to launch a hypersonic glide vehicle (HGV) to a high altitude, where the HGV then dives to an altitude with sufficiently thick atmosphere to enable the HGV to glide the rest of the way to

[13] Data compiled from U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China, 2021*, op. cit.; and, CSIS Missile Defense Project, "Missiles of China," op. cit.; and, Anthony Cordesman, Chinese Strategy and Military Forces in 2021, *CSIS*, August 3, 2021, available at https://www.csis.org/analysis/updated-report-chinese-strategy-and-military-forces-2021.

the target. This altitude is not fixed and depends on the vehicle design, reentry velocity and flight path angle, and the ballistic coefficient of the HGV. Figure 1 (which is illustrative and not to scale) compares several types of hypersonic weapons, plus subsonic cruise missiles.

Figure 1. Ballistic Missile versus Boost-Glide Missile versus Cruise Missile[14]



Altitude is in kilometers.

A boost-glide weapon has several *potential* advantages over a ballistic missile that does not possess a large amount of terminal maneuverability, especially for longer-range weapons:

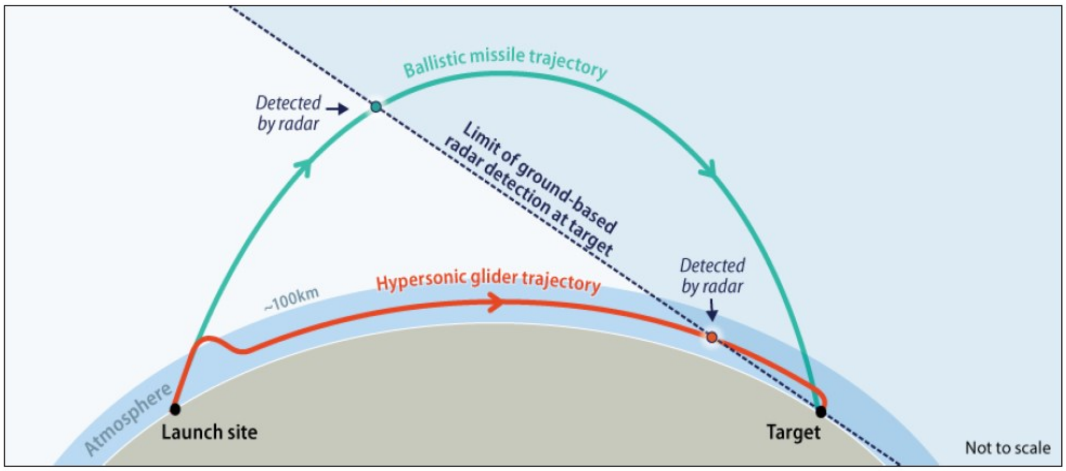
- A ballistic reentry vehicle (RV) would be at a very high altitude for most of its trajectory, which might allow enemy radars to track the RV for a long time. By contrast, radar would have a much shorter line of sight to an HGV. Figure 2 illustrates this phenomenon.
- An HGV could control its angle of impact at the target, whereas a purely ballistic RV could not. Such an ability could increase the lethality of a warhead—especially a conventional one but also a nuclear one.

---

[14] Figure created by authors from data compiled from Dennis Evans, *Strategic Arms Control Beyond New Start: Lessons from Prior Treaties and Recent Developments*, *National Security Report* (Johns Hopkins University Applied Physics Laboratory, LLC), 2021, available at https://www.jhuapl.edu/sites/default/files/2022-12/BeyondNewStart.pdf.

- Many BMD interceptors have a minimum intercept altitude exceeding the altitude at which the HGV would glide and would be ineffective against a boost-glide weapon.
- A boost-glide weapon would often have a longer range than a ballistic missile of the same size and payload weight.

Figure 2. Terrestrial Radar Detection of HGVs and Ballistic RVs[15]



Relative to a typical cruise missile, the primary advantages of a hypersonic weapon would be a shorter time of flight (useful for time-critical targets) and better survivability.

Current and near-term U.S. defenses are oriented towards BMD against traditional ballistic missiles and air-defense against aircraft and traditional cruise missiles. The U.S. ability to defend against hypersonic weapons are uncertain and possibly weak. The United States has programs underway to address hypersonic weapons, but major fielded capabilities are unlikely before the end of the decade.[16] Hence, an adversary that has a sizable inventory of HGVs, maneuvering ballistic missiles, and/or hypersonic cruise missiles would pose severe challenges to U.S. defenses, with effects that could easily be harshly adverse.

Unfortunately, China has robust research and development efforts on hypersonic weapons. In 2018, then Under Secretary of Defense for Research and Engineering Michael Griffin stated that China has conducted 20 times as many hypersonic tests as the United States. Also in 2018, John Hyten—the Vice Chairman of the Joint Chiefs of Staff—stated that China has conducted a hundred or more flight tests for hypersonic weapons compared to

---

[15] Figure in public domain, as seen in Kelley M. Sayler, *Hypersonic Weapons: Background and Issues for Congress* (Washington, D.C.: Congressional Research Service, May 5, 2022), p. 3, available at https://crsreports.congress.gov/product/pdf/R/R45811/25.

[16] U.S. Department of Defense, "Official Describes DOD Hypersonics Development, Strategy and Opportunities," *Defense.gov*, February 24, 2021, available at https://www.defense.gov/News/News-Stories/Article/Article/2514498/official-describes-dod-hypersonics-development-strategy-and-opportunities/; and, John Sawyer, *Missile Defense: Better Oversight and Coordination Needed for Counter-Hypersonic Development* (Washington, D.C.: Government Accountability Office, June 16, 2022), available at https://www.gao.gov/assets/gao-22-105075.pdf.

"single digits" for the United States. For example, China has used the Lingyun Mach 6+ high-speed engine test bed to research various hypersonic cruise missile technologies.[17] According to *Jane's Defence Weekly*, "China is also investing heavily in hypersonic ground testing facilities."[18]

Since 2014, China has tested the DF-17 boost-glide weapon more than seven times.[19] Although there is little information about the capabilities of the DF-17, the speed of the missile is reportedly around Mach 10.[20] The DF-17 is operational and equipped with a conventional warhead, but a future nuclear variant is possible. Mounting the same HGV on a larger booster would extend its range.[21]

A recent Chinese missile test, first reported in the *Financial Times* on October 16, 2021, has attracted considerable attention. According to the *Financial Times*, China launched an HGV on a space-launch vehicle that performed one complete orbit of the Earth before striking the ground in a Chinese test range.[22] If deployed on an ICBM booster stack, and still capable of reaching the United States on a trajectory over Antarctica, this weapon could pose two potential threats to the United States: a surprise attack and the ability to negate U.S. defenses at the planned sites. This missile could fly over Antarctica and approach the United States from the south, thereby avoiding detection by any U.S. ballistic missile early warning radar. U.S. satellites could detect the launch of such a missile, but the boost-phase track of the missile would provide little information about its intended target.

The U.S. Ground-based Midcourse Defense (GMD) system has two sites—one in Alaska and one in northern California. The GMD interceptor is limited to exo-atmospheric interceptions and is therefore ineffective against HGVs. However, even with an interceptor that works against HGVs, and a good ability to track weapons approaching from the south, interceptors at the current sites could not engage threats approaching the United States on that azimuth. The United States would need additional interceptor sites in the southern United States.

The magnitude of the threat from a Chinese boost-glide ICBM would depend on the yield of the warhead and accuracy of the missile. We cannot yet assess these factors.

To sum up, China may field sizable numbers of hypersonic weapons in this decade, and these Chinese weapons would likely pose severe challenges to U.S. defenses for a long time

---

[17] Jeffrey Lin and P.W. Singer, "China's Hypersonic Military Projects Include Spaceplanes and Rail Guns," *Popular Mechanics*, June 26, 2018, available at https://www.popsci.com/chinas-hypersonic-work-speeds-up.

[18] Andrew Tate, "China conducts further tests with hypersonic vehicles," *Janes Defence Weekly*, October 2, 2018, available at https://customer.janes.com/DefenceWeekly/Display/FG_1120806-JDW.

[19] CSIS Missile Defense Project, "DF-17," *CSIS*, August 2, 2021, available at China conducts further tests with hypersonic vehicles. The ability to achieve an increased range by mounting the same HGV on a larger rocket would depend on the quality of the thermal protection system on the HGV.

[20] "DF-ZF (formerly WU-14)" *GlobalSecurity.org*, no date, available at https://www.globalsecurity.org/wmd/world/china/df-21d.htm.

[21] Ajey Lele, *Disruptive Technologies for the Militaries and Security* (Singapore: Springer, 2019), pp. 71-74. It may be that the term WU-14 refers to the HGV whereas DF-17 refers to the overall missile system.

[22] Demetri Sevastopulo and Kathrin Hille, "China Tests New Space Capability With Hypersonic Missile," *FT*, October 16, 2021, available at https://www.ft.com/content/ba0a3cde-719b-4040-93cb-a486e1f843fb.

to come. Meanwhile, the number of U.S. flight tests of hypersonic weapons has been small, there are no developmental efforts on either nuclear or intercontinental hypersonic weapons, and no hypersonic weapons are likely to be produced in significant numbers for several years to come. In other words, hypersonic weapons have emerged as an important part of military technology, and China appears to be ahead of the United States—perhaps substantially so. No such situation has existed in the last 40 to 50 years, at least not in anything as important as hypersonic weapons. Further, the United States needs to, but may not, understand how these hypersonic weapons fit into overall Chinese strategy. How would China use such weapons? Against which targets? How early in a conflict? As it seeks to answer these questions, the United States should also address how hypersonic systems specifically fit into its own approach to deterrence and warfighting. Acquisition driven by adversary programs is an insufficient justification for the expense and effort associated with hypersonic offense and defense development. Fully exploiting the advantages of speed and maneuverability offered by hypersonic systems starts with the thoughtful application of these systems against U.S. operational problem sets, rather than by tit-for-tat attempts to maintain pace with adversary developments. From there, the United States can begin to consider how to remedy apparent weaknesses in the ability to develop and field systems that prevent it from ceding the military advantages offered by hypersonic to other countries.

Chinese Rationale for these Efforts

As previously discussed, China is engaged in a major nuclear buildup and is the world leader in hypersonic weapons—a worrisome combination. The key question for U.S. policy is: why has it done this? In addition, why has it done this *now*? China had the technology and economic resources to start a major nuclear buildup 15 years ago but did not do so. There is a range of possible rationales for China's strategic force activities, which includes:

- Growing concern about India's nuclear forces and rising geopolitical power;
- A desire to negate U.S. regional and national BMD systems;
- Fear of U.S. superiority in nuclear weapons;
- A perception that China will never be recognized as a true superpower until it has the nuclear arsenal of a superpower;
- A desire for world-class nuclear forces to deter actual or threatened U.S. nuclear escalation if China engages in regional aggression and the United States intervenes;
- A fear that a Chinese attempt to force reunification with Taiwan might bog down and fail without actual or threatened use of nuclear weapons;

- The growing perception of Chinese leaders that, in the event of a conflict, the United States might need to use nuclear weapons in defense of Taiwan;[23]
- A desire to obtain a range of nuclear escalation management capabilities;[24]
- A drive to achieve a damage limitation capability against U.S. nuclear forces; and
- Bureaucratic dynamics within China's nuclear weapons enterprise that are competing with one another to develop and offer novel weapons to decision makers.

The Chinese nuclear weapons program, on the other hand, cannot be viewed as a response to a U.S. nuclear buildup, because there is no such buildup. Current U.S. strategic nuclear programs of record are intended to replace aging systems, not quantitatively expand the U.S. nuclear arsenal or field new types of weapons. The U.S. nuclear program of record is discussed in detail later.

Further, this buildup, diversification, and modernization may lead to major changes in how China would use nuclear weapons. Until recently, the small numbers, poor accuracy, and high yields of Chinese nuclear weapons confined these weapons to use against cities and other counter-value targets. As the number of Chinese weapons increases, their accuracy improves, and low-yield weapons become available, China could make major changes in its nuclear strategy. To be specific, China may have a full counter-force capability in the 2030s that allows it to threaten U.S. nuclear force survivability in ways it previously could not. This is a fundamental shift in the balance of military utility and deterrent value of Chinese forces. As a result, a key challenge for U.S. deterrence policy is to shape a U.S. strategic force structure based upon an improved understanding of the rationale for Chinese actions, manifested in the numbers of weapons and delivery systems, the number of tests (especially successful ones), posture, and alert status. The full range of possibilities should be considered, to include the potential that China views its nuclear buildup as a valuable coercive tool to support offensive operations in service of regional expansion. Finally, U.S. nuclear force development needs to be conducted in light of the deterrence requirements imposed by Russia's legacy and emerging nuclear force posture. This force is discussed in detail in the following section.

Russian Behavior and Nuclear Weapons

Recent years have seen several worrisome trends in Russian behavior and nuclear force structure. Russia has been engaged in a full-scale modernization of its nuclear forces, fields a robust number of non-strategic nuclear weapons, and in 2022 demonstrated a

[23] Luo Xi, "Construction of all-domain winning strategic deterrent system by the U.S. and Sino-U.S. strategic stability," *Foreign Affairs Review*, Vol. 3, (2018), pp. 1-40. Also, see "Low-yield Nuclear Weapons May Change 'Nuclear Principles," *Xinhua News Agency*, August 01, 2019.

[24] Tong Zhao, "China's Silence on Nuclear Arms Buildup Fuels Speculation of Motives," *TheBulletin.org*, November 12, 2021, available at https://thebulletin.org/2021/11/chinas-silence-on-nuclear-arms-buildup-fuels-speculation-on-motives/.

willingness to employ conventional military forces in Russia's near-abroad, augmented with nuclear threats and signaling. The diversity of Russian nuclear systems, along with its hypersonic weapons, also raise questions about the adequacy of the existing bilateral strategic arms control regime to capture capabilities that give Russia the ability to inflict extensive damage on the U.S. homeland.

The Impact of Recent Weapons on Arms Control and Military Capabilities

Russia is modernizing its nuclear forces, including expanding its nonstrategic nuclear forces (and possibly even its total nuclear inventory). In terms of treaty-accountable strategic weapons (limited by the New Strategic Arms Reduction Treaty [New START]), Russia likely has slightly fewer warheads and delivery vehicles than the United States.[25] However, Russia has major qualitative and numerical advantages over the United States in NSNWs and probably has more nuclear weapons overall than does the United States. Figure 3 shows U.S. and Russian warhead levels over time. China—not shown in the figure—is currently at several hundred warheads, with a rapidly growing inventory.

Missiles

Russia has fielded and is developing new and potentially important weapons of types that the United States does not have and is not developing.[26] For example, Russia has recently fielded the Avangard boost-glide ICBM. This missile uses the booster stack from an existing silo-based ICBM and carries a nuclear HGV.[27] Corresponding U.S. efforts on boost-glide weapons are limited to intermediate-range conventional weapons. The impact of this probable U.S. disadvantage (relative to both Russia and China) on the balance of power and strategic stability warrants further consideration. In this case, a system capable of delivering a maneuvering glide vehicle at intercontinental ranges would likely be detected by U.S. sensors at launch but could pose challenges to the U.S. ability to track its full flight path and determine possible impact points. U.S. leaders could be presented with an incoming attack of uncertain objective with very limited time to take responsive actions.

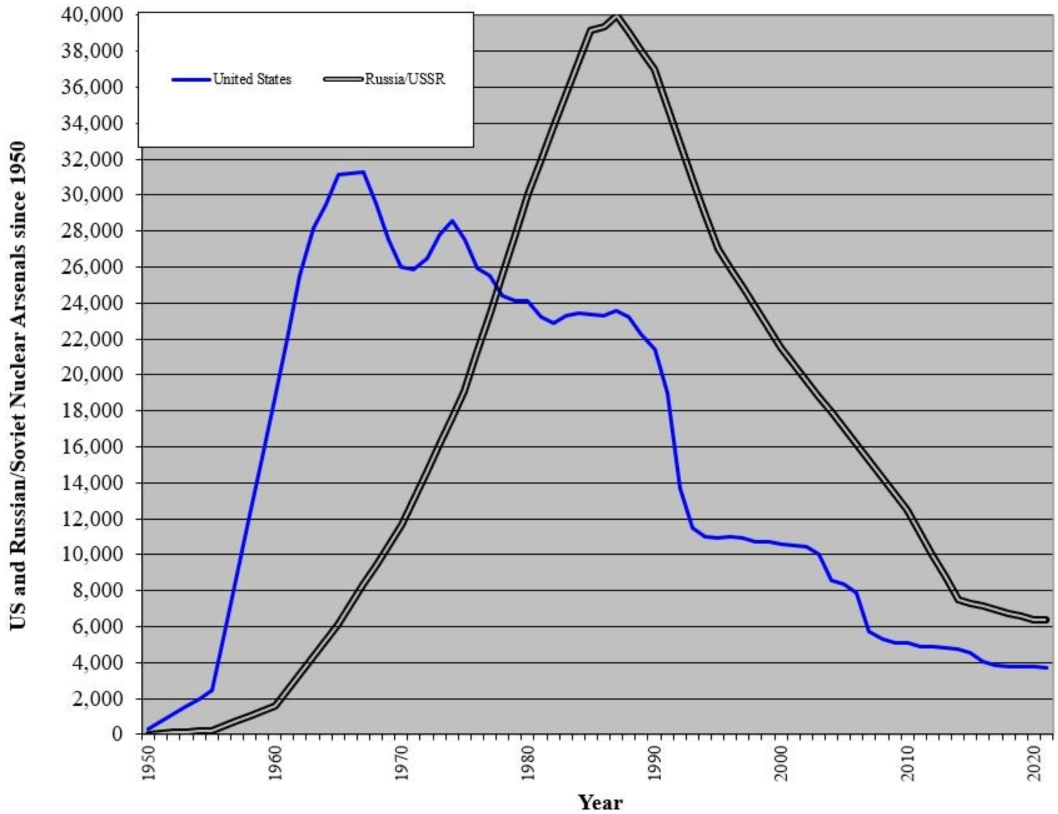
---

[25] U.S. Department of State, *Report to Congress on Implementation of the New START Treaty* (Washington, D.C.: Department of State, April 2021), available at https://www.state.gov/wp-content/uploads/2021/04/Annual-New-START-Report.pdf.

[26] U.S. Department of Defense, *Nuclear Matters Handbook 2020 (Revised)*, op. cit.; and, Amy Woolf, *The New START Treaty: Central Limits and Key Provisions* (Washington, D.C.: Congressional Research Service, July 30, 2021), available at https://sgp.fas.org/crs/nuke/R41219.pdf.; and, Dennis Evans, *Strategic Arms Control Beyond New START: Lessons from Prior Treaties and Recent Developments*, (Laurel, MD: JHU/APL, December 2021), available at https://www.jhuapl.edu/Content/documents/BeyondNewStart.pdf.

[27] CSIS Missile Defense Project, "Avangard," *CSIS*, July 31, 2021, available at https://missilethreat.csis.org/missile/avangard/.

Figure 3. U.S. and Soviet/Russian Warheads Levels over Time[28]



Russia has also fielded an ALBM with a range of perhaps 2,000 kilometers (according to Russian open-source literature)—called the Kh-47M2 Kinzhal (or Killjoy)—on Mig-31 fighters. Further, Russia has used this missile in combat against Ukraine. Russian open-literature articles also mention the Kinzhal in connection with the Su-34 fighter and the Tu-22M3 Backfire medium bomber, but the Mig-31 is the only confirmed delivery aircraft. The Kinzhal has a conventional version and may have a nuclear version.[29] With a nuclear version and a range of 2,000 kilometers, the Kinzhal would pose a major threat to NATO countries in Europe, and it could reach all of Alaska and parts of northwest Canada from

---

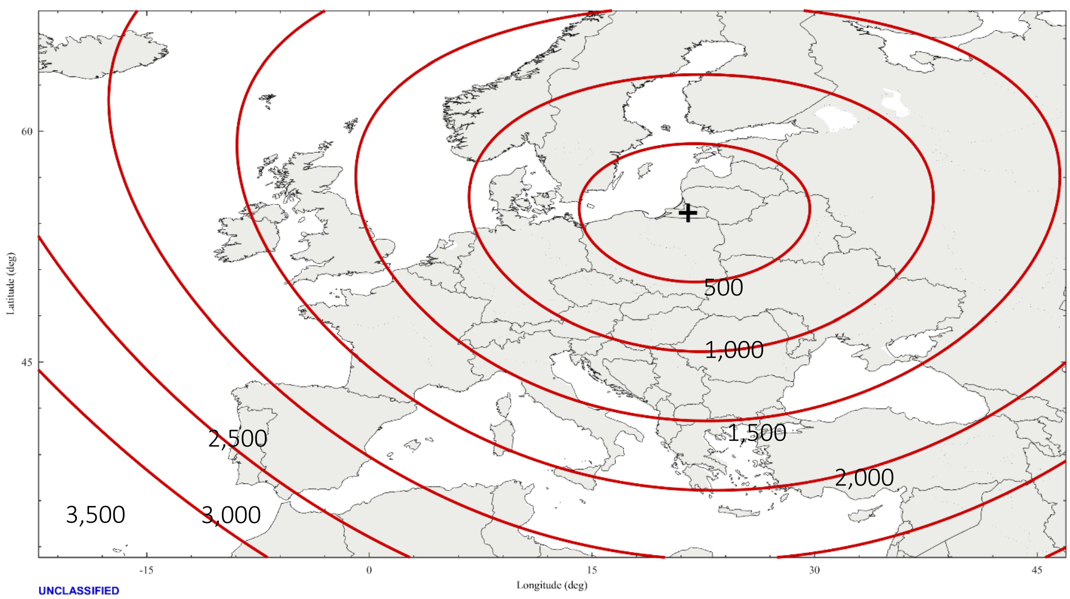
[28] Data concerning U.S. levels are from, U.S. Department of Defense, OSD DASD Nuclear Matters, *Nuclear Matters Handbook 2020 (Revised)* (Washington, D.C.: Department of Defense, 2020), available at https://www.acq.osd.mil/ncbdp/nm/NMHB2020rev/index.html. Data concerning Russian/Soviet levels are highly uncertain, but drawn from, Federation of American Scientists, "Status of World Nuclear Forces," *FAS.org*, no date, available at https://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/. Chinese warhead levels have historically been small by comparison but are growing rapidly.

[29] CSIS Missile Defense Project, "Kh-47M2 Kinzhal," *CSIS*, March 19, 2022, available at https://missilethreat.csis.org/missile/kinzhal/.

bases in eastern Siberia. If carried by the Backfire bomber, the Kinzhal could threaten much of North America.[30]

Russia is developing an intercontinental nuclear-powered, nuclear-tipped GLCM called the Burevestnik or Skyfall. The United States briefly fielded a few SM-62 Snark intercontinental GLCMs from 1958 through the early 1960s, but no country has fielded such a weapon since retirement of the Snark.[31] The lack of intercontinental GLCMs for decades was probably due to the perceived superiority of ICBMs, but technical loopholes on GLCMs in New START, combined with Russian concerns about U.S. BMD, may have provided incentives to revive such weapons.[32]

Figure 4. Geographic Coverage for SSC-8 GLCMs in Kaliningrad[33]



Ranges from the launch point appear as red rings, measured in kilometers. The CSIS estimate is 2,500 kilometers.

Russia has also fielded a GLCM, known as the SSC-8, which violated the Intermediate-range Nuclear Forces (INF) Treaty of 1987.[34] This missile led to the U.S. withdrawal from

[30] Woolf, *The New START Treaty: Central Limits and Key Provisions*, op. cit.; Amy Woolf, *Nonstrategic Nuclear Weapons* (Washington, DC: Congressional Research Service, July 15, 2021) available at https://sgp.fas.org/crs/nuke/RL32572.pdf.; and, Evans, *Strategic Arms Control Beyond New START: Lessons from Prior Treaties and Recent Developments*, op. cit.

[31] David E. Sanger and Andrew E. Kramer, "U.S. Officials Suspect New Nuclear Missile in Explosion That Killed 7 Russians," *The New York Times*, August 12, 2019, available at https://www.nytimes.com/2019/08/12/world/europe/russia-nuclear-accident-putin.html"

[32] Evans, *Strategic Arms Control Beyond New START: Lessons from Prior Treaties and Recent Developments*, op. cit.

[33] Figure created by authors from data compiled from Dennis Evans, Barry Hannah and Jonathan Schwalbe, *Nonstrategic Nuclear Forces: Moving Beyond the 2018 Nuclear Posture Review, National Security Perspective* (Johns Hopkins University Applied Physics Laboratory, LLC), 2018, available at https://www.jhuapl.edu/sites/default/files/2022-12/NonstrategicNuclearForces.pdf.

the INF Treaty in 2019. According to a briefing by then Director of National Intelligence, Dan Coats, the SSC-8 has both conventional and nuclear versions and a range “significantly in excess of 500 kilometers” (but not stated).[35] The Center for Strategic and International Studies (CSIS) assesses that the SSC-8 has a range of 2,500 kilometers.[36] With a range of 2,500 kilometers, a missile based in Kaliningrad could reach all of France, Italy, and the United Kingdom, plus parts of Spain and Iceland. Figure 4 shows target coverage for a Russian SSC-8 based in Kaliningrad, with the range varied parametrically from 500 kilometers (the INF limit) to 3,500 kilometers. The U.S. Government has not issued an unclassified range estimate for the SSC-8; thus, the figure treats its range parametrically, despite the CSIS estimate. If based in eastern Siberia, the SSC-8 could reach all of Alaska if its range is at least 1,700 kilometers. Strategic targets that the SSC-8 could probably attack from Siberia include the BMD radars at Clear, Alaska; the BMD interceptor site at Fort Greely, Alaska; and the Cobra Dane radar on Shemya Island. Because the United States has little ability to detect or defend against low-flying cruise missiles like the SSC-8, the SSC-8 might be able to knock out the U.S. GMD system before it could fire any interceptors.[37]

Sea-Based Systems

Russia is developing a nuclear-powered unmanned underwater vehicle (UUV). This UUV has intercontinental range, with autonomous navigation, and reportedly has a multi-megaton warhead. It may also be fast enough that it would be difficult for the United States to intercept it. Open literature articles refer to this weapon by several names, including Poseidon, Kanyon, and Status-6.[38] Kanyon is a new-in-principal weapon with no Cold War analog, although its range-yield combination places it squarely in the category of strategic weapons.[39]

---

[34] Amy Woolf, *Russian Compliance with the Intermediate Nuclear Forces (INF) Treaty: Background and Issues for Congress* (Washington, DC: Congressional Research Service, August 2, 2019), available at https://crsreports.congress.gov/product/pdf/R/R43832/38. Russia admits developing a new GLCM but denies that its range exceeds 500 kilometers. Russia also accuses the United States of violating the INF Treaty. Russia claims that the vertical launch system at the Aegis Ashore missile defense site in Romania can launch Tomahawk cruise missiles and not just missile defense interceptors.

[35] Office of the Director of National Intelligence, “Director of National Intelligence Daniel Coats on Russia’s INF Treaty Violation,” *DNI.gov*, November 30, 2018, available at https://www.dni.gov/index.php/newsroom/speeches-interviews/item/1923-director-of-national-intelligence-daniel-coats-on-russia-s-inf-treaty-violation.

[36] CSIS Missile Defense Project, “9M729 (SSC-8),” *CSIS*, March 31, 2022, available at https://missilethreat.csis.org/missile/ssc-8-novator-9m729/. The CSIS website did not specify whether the range estimate of 2,500 kilometers was for the nuclear version, the conventional version, or both.

[37] Evans, *Strategic Arms Control Beyond New START: Lessons from Prior Treaties and Recent Developments*, op. cit.

[38] The Diplomat, “Kanyon UUV,” *TheDiplomat.com*, March 11, 2019, available at https://thediplomat.com/tag/kanyon-uuv/.; and Kyle Mizokami, “Pentagon Document Confirms the Existence of Russian Doomsday Torpedo,” *Popular Mechanics*, January 16, 2018, available at https://www.popularmechanics.com/military/weapons/a15227656/pentagon-document-confirms-existence-of-russian-doomsday-torpedo/.

[39] Evans, *Strategic Arms Control Beyond New START: Lessons from Prior Treaties and Recent Developments*, op. cit.

Russia is also developing, and may have fielded, a ship-launched hypersonic missile known as Tsirkon. It is uncertain whether Tsirkon is a cruise missile, a boost-glide weapon, or a maneuvering ballistic missile. It may have both conventional and nuclear variants, and the range may be 1,000 kilometers or more.[40]

The threat to the United States from Russian submarine-launched cruise missiles (SLCMs) is more speculative than that from the SSC-8 but could be significant. Russia has several attack submarines that can carry Kalibr cruise missiles. The CSIS assesses that Russia's Kalibr SLCM has a conventional version, with a nuclear version being possible, and that the range of the missile is anywhere from 1,500 to 2,500 kilometers. The Federation of American Scientists (FAS) assesses that the Kalibr has both conventional and nuclear versions, and that the conventional version has a range of 2,000 kilometers.[41] If the Kalibr has a range exceeding 2,200 kilometers, then two Russian SSGNs could reach all 48 contiguous states from plausible launch points. It would require an implausibly large number of conventional SLCMs to achieve major strategic effects against the United States, whereas a few dozen nuclear SLCMs could have a major impact. A particularly worrisome application for nuclear SLCMs might be to destroy U.S. bombers on ground alert during a crisis. Bombers on ground alert might be able to take off fast enough to survive a first strike by Russian ICBMs or SLBMs, but submarines with SLCMs might be able to get very close to the U.S. coast (and many bases) before being detected.[42] This potential application highlights the ways in which different types of nuclear capabilities increasingly threaten the survivability of U.S. strategic forces.

Strategic Arms Control Overview

New START places limits on U.S. and Russian strategic forces without banning any particular types of weapons; it uses the following definitions to determine which weapons count against treaty limits:[43]

- *Ballistic missile* means a weapon-delivery vehicle that has a ballistic trajectory (an undefined term) over most of its flight path.
- *Cruise missile* means a self-propelled (an undefined term) weapon-delivery vehicle that sustains flight by using aerodynamic lift over most of its flight path.[44]

---

[40] Mark Episkopos, "What is Behind Russia's Hypersonic Tsirkon Missile?," *The National Interest*, January 29, 2022, available at https://nationalinterest.org/blog/reboot/what-behind-russia%E2%80%99s%C2%A0hypersonic%C2%A0tsirkon%C2%A0missile-200043.

[41] Hans M. Kristensen, "Kalibr: Savior of INF Treaty?" *FAS.org*, December 14, 2015, available at https://fas.org/blogs/security/2015/12/kalibr/.

[42] Evans, *Strategic Arms Control Beyond New START: Lessons from Prior Treaties and Recent Developments*, op. cit.; and, CSIS Missile Defense Project, "3M-54 Kalibr/Club (SS-N-27)," CSIS, March 31, 2022, available at https://missilethreat.csis.org/missile/ss-n-27-sizzler/.

[43] These observations are derived from the full text of the treaty and its appendices, U.S. Department of State, "New START: Treaty Text," *State.gov*, available at https://2009-2017.state.gov/t/avc/newstart/c44126.htm.

[44] Based on a discussion between JHU/APL personnel and the head of the division at the Pentagon that handles treaty compliance (Office of the Secretary of Defense – Acquisition and Sustainment – Strategic Warfare).

- *Submarine-launched ballistic missile (SLBM)* means a ballistic missile (nuclear or conventional) with a range exceeding 600 kilometers, of a type that has ever been carried by or launched from a submarine.
    - A ballistic missile on a surface ship would not automatically count against New START limits unless a submarine had also carried the same type of missile.
- *Intercontinental ballistic missile (ICBM)* means a land-based ballistic missile (conventional or nuclear) with a range exceeding 5,500 kilometers.
- *Heavy bomber* means a nuclear-capable aircraft with a one-way range exceeding 8,000 kilometers (without aerial refueling) or any aircraft that carries a nuclear ALCM with a range exceeding 600 kilometers.
    - A nuclear-capable aircraft with a range of less than 8,000 kilometers can carry conventional weapons of any range without counting against treaty limits if that bomber does not carry nuclear ALCMs with a range exceeding 600 kilometers.
    - An aircraft could carry a nuclear weapon of very long range without counting against New START limits if that aircraft has a one-way range of less than 8,000 kilometers and the weapon is not an ALCM.

New START limits the United States and Russia to 700 "deployed strategic delivery vehicles," 800 "total (i.e., deployed plus non-deployed) strategic delivery vehicles," and 1,550 "deployed warheads."[45] Each operational heavy bomber, ICBM, or SLBM counts as one deployed strategic delivery vehicle. Each usable, but empty, ICBM silo counts as one total delivery vehicle. Each empty SLBM tube on an SSBN in long-term overhaul also counts as one total delivery vehicle. (ICBMs and SLBMs in storage do not count.) Each heavy bomber in long-term maintenance counts as one total delivery vehicle. Each operational heavy bomber counts as one deployed warhead. An operational ICBM or SLBM with N warheads counts as N deployed warheads. New START places no limits on the number or nature of weapons carried by heavy bombers or on nuclear cruise missiles of any type.

In addition to their utility, boost-glide weapons do not meet the definition for either a ballistic missile or a cruise missile in New START; therefore, the United States and/or Russia could potentially field long-range boost-glide weapons while circumventing New START limits. The Russian Avangard boost-glide ICBM does count against New START limits, but only because it uses the booster stack from a weapon already declared to be an ICBM.

If the Russian Kinzhal ALBM has a nuclear version, it exploits a loophole in New START. Any aircraft that carries a nuclear ALCM with a range exceeding 600 kilometers counts against New START limits as a heavy bomber, without regard for the range of the aircraft or the number of weapons it can carry. Hence, if an aircraft were equipped with a nuclear

[45] U.S. Department of State, "New START: Treaty Text," op. cit.

ALCM having even one-third the postulated range of the Kinzhal, these aircraft would be heavy bombers under New START counting rules.[46] If all Mig-31 fighters were to count against New START limits, this would place Russia slightly in violation of the New START limit on deployed warheads.

Similarly, the Russian Skyfall GLCM and Kanyon UUV could function like a single-warhead ICBM or SLBM (albeit limited to coastal targets for the Kanyon) but without counting against New START limits. Although it has strategic importance—if it has a nuclear variant—the SSN-30 SLCM would never have counted against the limits in any arms control treaty. The SSC-8 GLCM violated the now-defunct INF Treaty but does not count against New START limits and would not have counted against the limits in any earlier strategic arms treaty.

Lastly, although it is not new and not an offensive threat to the United States, Russia has a potent BMD system that defends a small area around Moscow. This system consists of nuclear-tipped endo-atmospheric interceptors linked to a large Pill Box phased-array radar and various early warning radars.[47] Russian expansion of this system, replication of something like it at other locations, or augmentation of its BMD by integrating other types of capabilities (such as the future S-550) are all credible possibilities. Future Russian BMD improvements could affect U.S. requirements for strategic offensive capabilities, to include both force structure and in-flight survivability of U.S. reentry vehicles.[48]

In summary: Russia violated the INF Treaty and is aggressively exploiting loopholes in New START to field "strategic" weapons that do not count against New START limits. Some of these weapons pose a significant threat to NATO and the United States. In the near term, the Kalibr SLCM, the SSC-8 GLCM, and the Kinzhal ALBM represent significant risks, at least if the Kinzhal and Kalibr have nuclear versions (which is plausible or even likely). On the other hand, there is little threat to Russia from U.S. weapons that do not count against New START. This asymmetry operates strongly in Russia's favor, potentially enabling it to threaten U.S. and allied targets using systems that can be difficult to detect while being difficult for the United States to develop a proportionate response. *Moreover, the United States cannot afford to ignore Russian BMD, meaning that a robust technology research and development effort is needed to ensure the long-term capability of U.S. systems in the face of potentially evolving threats.*

The War in Ukraine

The Russian invasion of Ukraine that began February 24, 2022, has highlighted the continuing utility of hard military power in how states attempt to resolve disagreements.

---

[46] CSIS Missile Defense Project, "Kh-47M2 Kinzhal," op. cit.

[47] "Don-2NP Pill Box," *GlobalSecurity.org*, no date, available at https://www.globalsecurity.org/wmd/world/russia/pill_box.htm?msclkid=a6b6986ea2ff11ec938140aa3980a913.

[48] Sebastian Roblin, "Russia's New Mobile Missile Defense System Will Intercept Nuclear ICBMs," *The National Interest*, January 7, 2022, available at https://nationalinterest.org/blog/reboot/russias-new-mobile-missile-defense-system-will-intercept-nuclear-icbms-198905.

Furthermore, this invasion demonstrated reliance on nuclear signaling as a central element of Russia's strategy to deter Western involvement in the war. Only two days after the initial invasion, former president (and current deputy chairman of Russia's Security Council) Dmitri Medvedev threatened Russian withdrawal from the New START Treaty in response to U.S./Western economic sanctions. On February 27, President Vladimir Putin ordered Russian strategic forces to a special state of enhanced combat readiness. It is unclear how Putin's words relate to established Russian nuclear alert levels or to the U.S. DEFCON system. It is also unclear what changes actually occurred in the readiness or disposition of Russian nuclear forces after Putin's statement. Nonetheless, this was an alarming development. Despite the shocking nature of Russia's nuclear threats, such statements were in line with previous Russian behavior. Indeed, Russia previously relied on nuclear threats against the United States during the 2014 Ukraine crisis and the 2008 Georgia crisis/conflict.[49] Nevertheless, Russian battlefield setbacks in September and October suggest that the risk of Russian nuclear usage in Ukraine may be higher than was expected earlier in the war when Russian forces were performing better.[50]

The ongoing war in Ukraine has situated nuclear weapons at the center of great power relations and highlighted a number of implications for future deterrence consideration. First, this crisis is likely to exacerbate further the rift between the United States and Russia over how to proceed in negotiations over a New START follow-on treaty.[51] Political dynamics in both countries may preclude serious negotiations for a long while, in addition to the possibility that Russian actions and Western counteractions continue to destroy any remaining ability for the U.S. and Russian governments to find common ground on arms control. Second, the crisis has highlighted the disparity between Russian and U.S. NSNWs and the U.S. ability to match Russian nuclear escalation at lower levels of conflict. Russia possesses over a dozen types of NSNWs, numbering around 2,000, compared with the United States' single type of nuclear gravity bomb, the B61.[52] Lastly, the war in Ukraine may reinforce international perceptions of how the United States views the utility of its nuclear forces. Throughout the war, the United States has been clear in its intention to avoid escalation to a direct U.S.-Russia confrontation over Ukraine. This stands in contrast with U.S. treaty obligations to NATO collective security. By drawing a clear line between the interests of the United States in Ukraine versus those in NATO, the United States indirectly highlights that its nuclear weapons are reserved for certain interests and not others. The effect of this dynamic on U.S. deterrence against China, vis-à-vis Taiwan, is less

---

[49] Jonathan Cosgrove, *The Russian Invasion of the Crimea Peninsula, 2014-2015: A Post-Cold War Nuclear Crisis Case Study* (Laurel, MD: JHU/APL, 2020), available at https://www.jhuapl.edu/Content/documents/RussianInvasionCrimeanPeninsula.pdf.

[50] Jorge L. Ortiz, John Bacon, "Nuclear 'Armageddon' at highest risk since 1962, Biden says; Russia blames NATO for rhetoric: Live updates," *USA Today*, October 6, 2022, available at https://www.usatoday.com/story/news/world/2022/10/06/ukraine-russia-war-live-updates/8194683001/.

[51] New START will expire on February 5, 2026, and negotiations on treaties of this type can take years.

[52] U.S. Department of Defense, *U.S. Nuclear Weapons: Claims and Responses* (Washington, D.C.: Department of Defense, April 1, 2019), available at https://media.defense.gov/2019/Apr/01/2002108036/-1/-1/1/U.S.-NUCLEAR-WEAPONS-CLAIMS-AND-RESPONSES.PDF.

straightforward. Although the United States has a long-standing interest in Taiwanese security, it has no formal commitment to defend Taiwan as it does for nations that are part of NATO. President Biden recently made public comments indicating the United States would help Taiwan defend itself militarily, but this does not rise to the same level as a formal treaty of mutual defense, and the President did not extend the U.S. nuclear umbrella to the defense of Taiwan. This ambiguity – a commitment to Taiwan's security greater than to that of Ukraine but less than to NATO, Japan, or South Korea – can be useful as a way of inducing additional caution in Chinese decision makers but could also drive risk-taking by China if it believes the United States fears escalation more than China. The United States has run significant risks and absorbed costs to help Ukraine defend itself and to punish Russia's actions. These U.S. actions were consistent with U.S. threats against Russia before the start of the war in Ukraine, a fact that U.S. leadership could use to highlight China's need to take U.S. deterrent threats seriously.

Russia's Rationale for New Weapons and Their Recent Actions

Russia has at least three apparent rationales for developing the weapons mentioned above: to field weapons of strategic importance that evade New START limits;[53] to negate U.S. BMD systems, especially GMD; and to compensate for perceived U.S. superiority in conventional weapons. The first rationale could be part of a general drive for nuclear superiority (quantity, quality, and diversity). As for the second rationale, GMD is too small a system to have much utility against a Russian attack, but Russia may fear that the United States could conduct a first strike against them and rely on GMD to protect against a weak Russian counterattack.

Of the Russian weapons described previously, the rationale for the Avangard missile is the most confounding. A Russian attack could easily overwhelm GMD without Avangard. If Russia is concerned that GMD could negate a Russian counterattack after a U.S. first strike, it is not enough for the Russian system to be immune to U.S. BMD. The Russian system has to survive the U.S. first strike, and silo-based ICBMs like Avangard are not optimal for surviving a first strike. This raises a key question: could Avangard be a first strike weapon instead? If so, there are a number of issues that the United States needs to consider, including how to limit the number of such systems, how to detect and track the system before and during flight, and potential ways of defending against the system.

The SSC-8 GLCM, Skyfall intercontinental GLCM, Kanyon UUV, and SSN-30 SLCM satisfy both rationales, if the SSN-30 has a nuclear variant. All four weapons would be hard for the United States to destroy in a first strike, and all four could negate U.S. BMD.

Because of Russia's concerns over its strategic depth, its aggressive intentions, and a conventionally superior NATO positioned on its borders, regional nuclear weapons make a

[53] The Kinzhal ALBM is operational now. If Kinzhal has a nuclear variant, then it exploits a loophole in New START. The Kanyon UUV may be operational before New START expires. If so, it would also exploit a loophole in New START. It is uncertain whether the intercontinental GLCM will be deployed by 2026.

lot of sense as a way to deter NATO involvement, manage escalation, and achieve objectives in a limited war. Both the Tsirkon and the SSC-8 are major threats to NATO bases in Europe.

As for Vladimir Putin's belligerent statements about nuclear weapons, and the increased alert posture of Russian forces, the motive is uncertain. Did he think that nuclear posturing will get NATO to agree to a list of demands he sent to NATO shortly before starting the war? If so, he has surely been disappointed. Does he really fear NATO military intervention (beyond providing arms to Ukraine)? If so, is this an attempt to deter such an act? Is he willing to use nuclear weapons in a medium-scale conventional war if Russian aggression appears to be failing? Whatever the motivation, Putin's recent actions are concerning, and a better understanding of their drivers is required.

North Korea and the BMD Conundrum

The North Korean nuclear program has long been a source of concern (as have the as-yet unsuccessful efforts in Iran). However, North Korean nuclear forces have continued to grow in the last five years at a rapid rate. In particular, North Korean ICBMs pose more of a threat to the U.S. homeland than was probably expected a few years ago, and this threat is growing steadily. This has resulted in a shift away from credible nuclear threats directed primarily against North Korea's neighbors toward direct threats to the U.S. homeland. Because Kim Jong Un has stated that North Korea would not give up its nuclear forces under any circumstances, no matter what inducements the United States and its allies offered, the United States is likely to continue prioritizing missile defense capabilities against regional powers such as North Korea. This results in a continuing dilemma, where U.S. missile defense programs intended to ward off threats from smaller nuclear powers are interpreted by its great power adversaries as threats to the viability of their deterrent forces.

North Korea probably has several dozen nuclear weapons and has fielded ICBMs that can reach the 48 contiguous states; these ICBMs are purely focused on nuclear missions.[54] North Korea also recently tested a boost-glide missile of theater range, although it is uncertain whether this missile is nuclear-capable. Table also summarizes North Korean land-based missiles that may have enough range to reach Guam. It is not certain which, if any, of the theater-range missiles have nuclear variants. North Korea also has one or two diesel-powered ballistic missile submarines, but the lack of nuclear propulsion and the apparently short range of the North Korean SLBM mean that these submarines are only a regional threat.[55] North Korea also has a sizable inventory of missiles that can reach Japan but not Guam. These missiles are not included in Table 2.

---

[54] Mary Beth D. Nikitin, *North Korea's Nuclear Weapons and Missile Programs* (Washington, D.C.: Congressional Research Service, April 8, 2022), CRS Report No. IF10472, available at https://crsreports.congress.gov/product/pdf/IF/IF10472/22.

[55] CSIS Missile Defense Project, "Missiles of North Korea," *CSIS*, November 22, 2022, available at https://missilethreat.csis.org/country/dprk/.

Table 2. North Korean Ballistic Missiles and Boost-Glide Weapons[56]

Name of System	Type	Range (kilometers)	Status
Hwasong-7	Boost-glide MRBM or IRBM	Uncertain	Development
BM-25 Musudan	IRBM	2,500 to 4,000	Possibly fielded
Hwasong-12	IRBM	>4,000	Development
Hwasong-13	ICBM	>5,500	Probably canceled
Hwasong-14 (KN-20)	ICBM	10,400	Fielded
Hwasong-15 (KN-22)	ICBM	>11,000	Development
Pukguksong-1 (KN-11)	SLBM	1,100	Possibly canceled
Pukguksong-3 (KN-26)	SLBM	1,900	Fielded

The BMD Conundrum

The U.S. GMD system is intended to protect against a North Korean attack. GMD consists of 44 interceptors (40 in Alaska, with 20 more planned, and 4 in California), plus a complex command and control system integrated with missile warning satellites and multiple ground-based radars. There have been no physical tests of multiple interceptors fired against multiple incoming missiles. (There have been simulated tests of such engagements and a test of multiple interceptors against a single target.)[57] Hence, there is no way to be certain how well GMD would function against a real attack with a sizable number of enemy missiles approaching simultaneously. Further, the faster-than-expected growth in North Korean ICBMs may necessitate expansion of GMD beyond currently planned numbers.

The United States expects Russia and China to realize that GMD is not focused on negating their nuclear strike capability—but they do not, or at least they claim they fear GMD as a threat to their secure retaliatory capability. It is uncertain whether these concerns are genuine or just posturing. The size of the GMD system has not increased since President George W. Bush left office and, even with the planned expansion to 64 interceptors, the number of interceptors will be small relative to the number of Russian or Chinese ICBM/SLBM RVs today. Nevertheless, fears that the United States will expand GMD

[56] Data synthesized from Nikitin, *North Korea's Nuclear Weapons and Missile Programs*, op. cit.; and, CSIS Missile Defense Project, "Missiles of North Korea," op. cit. The KN-22 ICBM is of particular concern. The KN-22 can likely reach all 50 states, and it may be able to carry multiple warheads. Further, the missile is mobile despite its large size, making it harder for the United States to locate it in advance of a launch.

[57] Alex Hollings, "U.S. Mainland Missile Defense System Successfully Intercepts ICBM in Test," *FighterSweep.com*, March 31, 2019, available at https://fightersweep.com/12318/us-mainland-missile-defense-system-successfully-intercepts-icbm-in-test/.

beyond 64 interceptors may have contributed to the Chinese decision to beef up their nuclear forces and Russia's development of strategic weapons that are immune to U.S. BMD. Future expansion of GMD may lead to additional adverse actions by Russia or China. Unfortunately, the North Korean threat is real and growing. How can the United States protect itself without provoking undesirable responses by Russia or China? Once again, a better understanding of how U.S. missile defenses influence Russian and Chinese decisions concerning their nuclear forces would be helpful. That being said, it may be impossible for the United States to field any system for defense against North Korean missiles that is not used self-servingly by Russia or China as justification for programs they were otherwise intending to pursue.

Implications for Deterrence Theory, Arms Control, and U.S. Capabilities

Deterrence Theory

Since the end of the Cold War, deterrence theory has been advanced by key scholars such as Keith Payne and Brad Roberts. A body of work has evolved that seeks to understand how crises could escalate, driven by emerging technologies, and how deterrence theory could apply to challenges like transnational terrorism. However, at its core, deterrence does still rely on the idea of denying benefits, imposing costs, and encouraging restraint between multiple parties. The legacy models of first strike stability and other deterrence measures need continued advancement to address the possible impact from new types of weapons, potential improvements in missile defenses, the impact of small but hostile nuclear powers, or a world where the United States must simultaneously deter two major nuclear powers, who are increasingly aligned with one another. This last point is particularly salient today, as the United States faces the prospect of deterring a Russian nuclear force replete with new capabilities (including dangerous new systems that do not count against New START limits but pose a threat to NATO and the U.S. homeland) and a Chinese nuclear force growing in size far beyond historical precedent and perhaps rivaling planned U.S. forces. A simplistic application of some legacy approaches to deterrence might suggest a need for the United States to exit the New START treaty and undertake a rapid nuclear buildup to ensure sufficient numbers of survivable nuclear forces available for the coming decades. While the United States may very well need to undertake a nuclear buildup of some kind in response to current trends, it is not clear that this is politically feasible. What approaches could be developed instead? Further work is needed in this area, and theories and models need to evolve to account for the trend towards a tripolar world, nuclear threats from smaller countries, and the full range of modern weapon types. In particular, the United States needs a better understanding of how to integrate capabilities across domains and to account for the roles of nuclear weapons, long-range conventional weapons (especially hypersonic weapons), and missile defense in reinforcing or undermining deterrence and strategic stability. As Alexander George points out in his classic study of presidential decision making, the limits of classical deterrence theory lie in its inability to "provide a more comprehensive formulation of the various means of influencing other states and an analysis of how they can be combined to achieve foreign-policy goals under different conditions."[58] Going forward, the application of these various means, together with judicious and prudent application of resources for new deterrence capabilities, is likely to enable a more effective U.S. response to the international geopolitical situation than simply relying on a long-term nuclear build-up of great difficulty.

At the same time, the United States needs to improve its approach to assessing military threats posed by great power competitors and determining how best to prioritize and maintain focus on deterring those threats over long periods. Given the challenging nature of today's tripolar nuclear world, this may require significant strategic decisions in order to continue deterring Russia and China in the best manner, tailored for the unique strategic threats they each pose.

Arms Control

All treaties limiting the size and nature of nuclear forces have been bilateral agreements between the United States and Russia (formerly the Soviet Union). However, continued Chinese nuclear expansion may render bilateral U.S.-Russian treaties irrelevant or undesirable before long. A key question for future U.S. policy consideration revolves around when Chinese and Russian nuclear force levels reach a tipping point. In other words, when does the United States focus need to shift from pursuing stability and predictability through arms control to embarking on its own nuclear buildup?[59] If China continues its nuclear buildup and Russia continues to field strategically important weapons that are exempt from arms control (such as the SSC-8, Kalibr, Kinzhal, Poseidon, and Tsirkon), arms control as practiced in the last few decades may not be the best approach to stability. This question should be answered in tandem with considerations around how theoretical concepts surrounding deterrence need to evolve. It may be that the various tools available to the United States to deter Russia and China allow it to continue indefinitely with roughly the same quantitative nuclear force capabilities while relying on modernization to ensure a sufficient qualitative edge. That being said, the sheer number and diversity of weapons being developed by Russia and China highlight the need to think critically about the ways in which the United States could credibly deter Russia and China at various levels of crisis escalation.

---

[58] Alexander L. George, *Presidential Decision-making in Foreign Policy: The Effective Use of Information and Advice* (Boulder, CO: Westview Press, 1980), p. 255.

[59] Opinions vary on the extent to which arms control has enhanced stability and predictability in the past. However, arms control has reduced expenditures on strategic weapons by capping force levels.

Additionally, there should be continued thought given to ways the United States can induce China to participate in future arms control-related activities. Even if China agrees to participate, it may be difficult to construct an acceptable treaty—limits, definitions, counting rules, and so on. For example, each participant might worry, or at least claim to worry, about having the other two countries unite against it. More broadly, how can the United States respond to the Chinese buildup without abandoning constraints on Russian forces, and without abandoning requirements for Russia to report on its strategic forces and allow U.S. inspections of those forces? These requirements on reporting and inspections are important even without limits on U.S. and Russian force levels.

That being said, the United States is entering a period where new arms control agreements may need to depart in novel ways from those of the past (for example, agreements that include China, that address supposed Russian concerns over U.S. BMD, or that address U.S. concerns over Russian NSNWs).[60] Unfortunately, such agreements are probably unattainable in the coming decade unless U.S.-Russian relations improve, and China achieves its desired nuclear weapons force structure or otherwise shows a willingness to negotiate. As a result, the United States needs to begin hedging for a world in which there are greater demands on its nuclear forces, not fewer. This will also mean increased demands on other national capabilities, such as intelligence resources to monitor Russian and Chinese nuclear developments that would normally have been illuminated (at least for Russia) by treaty-required inspection and verification regimes.

U.S. Needs for Missile Defense, Nuclear Forces, and Long-Range Strike

The Chinese, Russian, and North Korean developments described previously may drive requirements for U.S. forces beyond what is in the program of record—both numerically and in terms of capabilities. All U.S. decisions on force structure objectives for strategic systems date back to the Obama Administration, with the exceptions of the W76-2 and SLCM-N. Hence, these decisions predated the Chinese nuclear buildup, the recent developments in Chinese hypersonic weapons, and Russian fielding of weapons such as the Poseidon, Kinzhal, and Tsirkon.[61]. Further, U.S. decisions on offensive force structure also date back to a time when the North Korean threat to the U.S. homeland was much less severe than it is likely to be later in this decade, although North Korean forces are not a key driver for the size of U.S. nuclear forces. However, North Korea could drive U.S. capability needs in ways that are not obvious.

The next few paragraphs describe the U.S. program of record.

[60] One possibility might be to have a treaty that counts strategic BMD interceptors for homeland defense and strategic offensive weapons against one overall limit. This concept has many complexities, but further examination may be warranted. This approach would avoid explicit, low limits on U.S. BMD.

[61] Kalibr and the SSC-8 may have been fielded in small numbers by the end of the Obama Administration, but the threat from these two weapons is greater than it was in 2017.

Currently, the United States plans to procure 12 *Columbia*-class SSBNs, each with 16 Trident D5 SLBMs. On the average, 11 of these 12 SSBNs would probably be operational at any time. The United States currently has 14 *Ohio*-class SSBNs, of which 12 are usually operational. Each *Ohio*-class SSBN can carry 20 Trident D5 SLBMs. Due to the late start of the *Columbia* program relative to the projected retirement dates for *Ohio*-class SSBNs, the number of SSBNs will drop to ten for several years, even with no delays in projected deliveries for new SSBNs (160 deployed SLBMs compared to 240 today).[62] The United States is keeping the nuclear SLCM that the 2018 NPR endorsed, but only at modest research and development funding levels, although it has deployed a low-yield W76-2 warhead on submarine-launched ballistic missiles.[63]

The United States currently has 400 deployed single-warhead Minuteman III ICBMs.[64] The United States is developing the Sentinel ICBM and plans to deploy 400 in existing silos, but it would be possible to deploy 450 ICBMs without building additional silos (because there are 50 empty but usable silos). There has been no announcement on whether any of the future ICBMs will carry multiple warheads. Production of the Sentinel ICBM may begin in 2026.[65]

The United States has 60 deployed nuclear-capable bombers (44 B-52s and 16 B-2s) and 66 total nuclear bombers (47 B-52s and 19 B-2s). The United States also has 29 B-52s and 45 B-1s that are not nuclear-capable. The United States is developing the B-21 Raider stealth bomber, with a stated procurement objective of "at least 100" aircraft. The United States has not announced whether all B-21s will be nuclear-capable or whether any B-21s will have nuclear weapons in 2030. Deliveries of the B-21 are expected to begin in the middle 2020s. DOD plans to retire the B-2 (and the non-nuclear B-1) in the early 2030s. The United States is developing the Long-Range Standoff (LRSO) nuclear ALCM for use by the B-52 and the B-21. The LRSO is expected to begin replacing the current AGM-86 ALCM around 2030.[66] The B61-12 nuclear bomb is in early production for use by the B-2, the F-35A, and (in a few years) the B-21.[67] On the other hand, the United States recently decided

[62] Office of the Chief of Naval Operations, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2023* (Washington, D.C.: Office of the Chief of Naval Operations, April 2022), available at https://media.defense.gov/2022/Apr/20/2002980535/-1/-1/0/PB23%20SHIPBUILDING%20PLAN%2018%20APR%202022%20FINAL.PDF.

[63] John Rood, "Statement on the Fielding of the W76-2 Low-Yield Submarine Launched Ballistic Missile Warhead," *Defense.gov*, February 4, 2020, available at https://www.defense.gov/News/Releases/Release/Article/2073532/statement-on-the-fielding-of-the-w76-2-low-yield-submarine-launched-ballistic-m/.

[64] The number of nuclear-capable bombers is 66. The United States declared 60 of them to be deployed, but the number of operational bombers is typically about five-sixths of the total (that is, about 55).

[65] Northrop Grumman, "Sentinel – The Ground Based Strategic Deterrent," no date, available at https://www.northropgrumman.com/space/sentinel/.

[66] Greg Hadley, "Raytheon Receives $2 Billion EMD Contract for LRSO Missiles," *Air and Space Forces Magazine*, July 1, 2021, available at https://www.airandspaceforces.com/raytheon-receives-2-billion-emd-contract-for-lrso-missiles/.

[67] U.S. Air Force, "B-21 Raider," *AF.mil*, no date, available at https://www.af.mil/About-Us/Fact-Sheets/Display/Article/2682973/b-21-raider/msclkid/b-21-raider/. This document describes the B-21 as being nuclear-capable, but the United States could not accommodate 100 nuclear-capable B-21s and 47 nuclear-capable B-52s within

on prompt retirement for its highest-yield nuclear bomb, the B83-1, instead of keeping it as long as practical without a major life-extension program.[68]

The United States has 700 deployed delivery vehicles—compared to about 820 in 2010. If the Air Force fields the Sentinel ICBM rapidly enough for the ICBM force to stay at 400 missiles continuously, and the number of deployed nuclear-capable bombers stays at 60 through 2040, then the number of U.S. delivery vehicles will drop to 620 in the 2030s before building back up to 652 in the early 2040s. The United States has not initiated any new nuclear weapon program since the Obama administration, has decided not to continue with the nuclear SLCM that was envisioned in 2020, and has decided to retire the B83-1 bomb promptly.[69] In other words, there is no U.S. nuclear buildup, although the Sentinel ICBM will presumably have some technical advantages over the Minuteman III. It is hard to compare the B-21 to the B-2, but the B-21 will reportedly be smaller than the B-2, with a possible adverse effect on payload and/or range.[70]

Due to the various adverse developments described earlier in this paper, the United States may need additional measures to account for a tripolar nuclear world. These measures might include an expansion in force structure, steps to make a force of the planned size more survivable, improved capabilities, or some combination thereof. Hence, the United States needs to examine the advantages, disadvantages, and costs of various approaches that could make U.S. forces more robust in a tripolar nuclear world, including:

- Deploying more than 400 ICBMs and/or carrying more than one RV on some ICBMs;
- Replacing the current silos with harder silos and/or adding BMD systems at ICBM bases, to improve ICBM survivability;
  - Russian modernization and the Chinese ICBM buildup suggest that the threats to U.S. ICBMs may be increasing. This provides impetus for measures to improve pre-launch survivability.
  - BMD at an ICBM base can be useful without being nearly 100-percent effective, unlike BMD for defending cities or SSBN bases. This is not to say that imperfect defenses are desirable, but ICBM bases provide a case where leaky defenses may be good enough.
- Steps to improve the survivability of bombers on ground alert;
  - The Kalibr SLCM may pose a threat to bombers on ground alert if it has a nuclear version. This provides impetus for such steps.
- Improving the in-flight survivability of U.S. ICBMs and SLBMs;

New START limits, in combination with 400 or more ICBMs and 192 SLBMs. As noted earlier, however, New START limits may be irrelevant by 2026.

[68] Bill Gertz, "Pentagon to Scrap Nuclear Gravity Bomb as Part of Biden Review," *The Washington Times*, April 4, 2022, available at https://www.washingtontimes.com/news/2022/apr/4/pentagon-scrap-nuclear-gravity-bomb-part-biden-rev/.

[69] The low-yield Trident D5 employs a simple modification to an existing warhead, not a new weapon per se.

[70] "Comparing Stealth Bombers," *Air and Space Forces Magazine*, December 2019, available at https://www.airandspaceforces.com/app/uploads/2019/12/Comparing-stealth-bombers-1.pdf.

- Procuring more than 12 *Columbia*-class SSBNs, and/or accelerating procurement of the third *Columbia*-class SSBN from 2026 to 2025 (if practical);
- Increasing the number of nuclear-capable B-21 bombers and/or increasing the nuclear weapon inventory for bombers;
  - Increasing the weapon inventory for bombers without expanding the bomber force would have no effect on U.S. compliance with New START but might have merit.
  - It would be desirable to increase the number of bomber bases and reduce the number of bombers per base. This would increase the number of bombers that could take off under attack during an enemy first strike.
  - Maximizing the utility of an expanded bomber force might also require steps to improve the survivability of bombers on ground alert.
- Expanding and improving GMD (beyond the planned 64 interceptors) because of the growing North Korean threat;
- Keeping the B83-1 longer than currently planned (possibly including an unfunded life-extension effort) and/or pursuing other ways to improve capabilities against hard and deeply buried targets;
- Deploying nuclear weapons of types not in the current program of record, including ones that might not count against arms-control limits similar to those in New START; and
  - No such new weapons could be operational before New START expires but having acquisition programs for such weapons could provide leverage in negotiations for a successor treaty (if any such negotiations occur). Moreover, having effective weapons that are exempt from arms control could be beneficial in the 2030s if there is a successor treaty with definitions and other provisions similar to New START.
- Having more robust programs for conventional hypersonic weapons, and/or deploying defenses against such weapons, especially in the Pacific.[71]

[71] Space does not permit a robust discussion on U.S. hypersonic weapons or defenses against such weapons. Interested readers should consult three reports from the Congressional Research Service, all of which may be found at https://crsreports.congress.gov/. Kelley Sayler and Stephen McCall, *Hypersonic Missile Defense: Issues for Congress* (Washington, D.C.: Congressional Research Service, January 26, 2022).; and, Andrew Feickert, *The U.S. Army's Long-Range Hypersonic Weapon* (Washington D.C.: Congressional Research Service, December 8, 2021).; and, Kelley Sayler, *Hypersonic Weapons: Background and Issues for Congress* (Washington. D.C.: Congressional Research Service, May 23, 2022).; and, John Sawyer, *Missile Defense: Better Oversight and Coordination Needed for Counter-Hypersonic Development* (Washington D.C.: Government Accountability Office, June 16, 2022), GAO 22-105075, available at https://www.gao.gov/assets/gao-22-105075.pdf.

Conclusion

Russian, Chinese, and North Korean developments suggest a fundamental, adverse change in the world security environment. This is evident in the increased numbers of strategic weapons and delivery systems, the diversity of options (e.g., China will have at least three different kinds of silo-based ICBMs capable of reaching the United States), each country's approach to nuclear posture, and the alert status of each country's weapons. These developments represent a security environment without precedent. Unlike in the Cold War, the United States could be faced with needing to deter two or more major adversaries at a time, but with fewer options and a decreased number of overall weapons. The United States needs to give fresh thought to all aspects of strategic force structure and strategy, to include efforts to rethink deterrence theory and arms control for a tripolar world with additional risks from North Korea.

Bibliography

Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2021. Washington, DC: Office of the Secretary of Defense, November 2021.

"As China Speeds Up Nuclear Arms Race, the US Wants to Talk." *New York Times*. November 28, 2021.

"BGM-109 Ground Launched Cruise Missile." Federation of American Scientists. Last updated December 20, 1997. http://fas.org/nuke/guide/usa/theater/glcm.htm.

Cordesman, Anthony H., Ashley Hess, and Nicholas S. Yarosh. *Chinese Military Modernization and Force Development: A Western Perspective*. Washington, DC: Center for Strategic and International Studies, September 2013.

Cunningham, Fiona, and Taylor Fravel. "Dangerous Confidence: Chinese Views on Nuclear Escalation." *International Security* 44, no. 2 (2022): 65–109.

"Current Status." Russian Strategic Nuclear Forces. June 20, 2017. http://russianforces.org/current.

Evans, Dennis, Barry Hannah, and Jonathan Schwalbe. *Nonstrategic Nuclear Forces: Moving Beyond the 2018 Nuclear Posture Review*. National Security Report NSAD-R-16-001. Laurel, MD: Johns Hopkins University Applied Physics Laboratory, 2017.

Feickert, Andrew. *The U.S. Army's Long-Range Hypersonic Weapon*. Washington, DC: Congressional Research Service, May 23, 2022.

Frankel, Michael, James Scouras, and George Ullrich. *Nonstrategic Nuclear Weapons at an Inflection Point*. National Security Perspective NSAD-R-17-024. Laurel, MD: Johns Hopkins University Applied Physics Laboratory, 2017.

Gunzinger, Mark, Carl Rehberg, and Gillian Evans. *Sustaining the U.S. Nuclear Deterrent: the LRSO and GBSD*. Washington, DC: Center for Strategic and Budgetary Assessments, April 2018.

Hitchens, Theresa. “Hypersonic Space Test Fuels Sino-American Arms Race.” *Breaking Defense*. October 21, 2021.

Kristensen, Hans M., and Robert S. Norris. “Russian Nuclear Forces, 2016.” *Bulletin of the Atomic Scientists* 72, no. 3 (2016): 125–134.

Long, Austin. “Discrimination Details Matter: Clarifying an Argument About Low-Yield Nuclear Warheads.” *The RAND Blog*, February 16, 2018. https://www.rand.org/blog/2018/02/discrimination-details-matter-clarifying-an-argument.html.

Maintaining Advantage in a Multi-Polar Nuclear World. Washington, DC: Office of Net Assessment, Office of the Secretary of Defense, January 2006.

National Nuclear Security Administration. *Fiscal Year 2020 Stockpile Stewardship and Management Plan—Biennial Plan Summary, Report to Congress.* Washington, DC: U.S. Department of Energy, March 2019.

Nikitin, Mary Beth. *North Korea’s Nuclear Weapons and Missile Programs*. Washington, DC: Congressional Research Service, April 8, 2022.

Radzinsky, Brian. “Chinese Views of the Changing Nuclear Balance.” *War on the Rocks*. October 22, 2021.

A Report of the PONI Working Group on U.S.–China Nuclear Dynamics: Nuclear Weapons and U.S.–China Relations—A Way Forward. Washington, DC: Center for Strategic and International Studies, March 2013.

Sanger, David, and William Broad. “A 2nd New Nuclear Missile Base for China, and Many Questions About Strategy.” *New York Times*. July 27, 2021.

Sawyer, John. *Missile Defense: Better Oversight and Coordination Needed for Counter-Hypersonic Development*. Washington, DC; Government Accountability Office, June 16, 2022

Sayler, Kelley M. *Hypersonic Weapons: Background and Issues for Congress*. Washington, DC: Congressional Research Service, May 5, 2022.

———. *Hypersonic Missile Defense: Issues for Congress*. Washington, DC: Congressional Research Service, January 26, 2022.

Schneider, Mark. “The Massive Expansion of China’s Strategic Nuclear Capability.” *Real Clear Defense* (realcleardefense.com). July 20, 2021.

Sutton, H.I., “Chinese Navy Steps Closer to New Generation of Nuclear Submarines.” *Forbes Online*. June 19, 2020.

Talmadge, Caitlin. “Would China Go Nuclear?” *International Security* 41, no. 4 (2017): 50–92.

The Tenth China-US Dialogue on Strategic Nuclear Dynamics. Pacforum.org. June 2016.

Ullrich, George W., James Scouras, and Michael J. Frankel. J., “Nonstrategic Nuclear Weapons: The Neglected Stepchild of Nuclear Arms Control.” *Air and Space Power Journal* 31, no. 1 (2015): 9–14.

U.S. Department of Defense. *Nuclear Posture Review Report*. Washington, DC: Office of the Secretary of Defense, April 2010.

———. *Nuclear Posture Review*. Washington, DC: Office of the Secretary of Defense, February 2018.

———. *Nuclear Posture Review*. Washington, DC: Office of the Secretary of Defense, October 2022.U.S. Department of Defense, Defense Science Board Permanent Task Force on Nuclear Weapons Surety. *Air Force Nuclear Enterprise Follow-on Review*. Washington, DC: Office of the Secretary of Defense, April 2013.

Woolf, Amy F. *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues*. Washington, DC: Congressional Research Service, July 16, 2021.

———. *The New START Treaty: Central Limits and Key Provisions*. Washington, DC: Congressional Research Service, February 2, 2022.

———. *Nonstrategic Nuclear Weapons*. Washington, DC: Congressional Research Service, March 7, 2022.

———. *Russian Compliance with the Intermediate Nuclear Forces (INF) Treaty: Background and Issues for Congress*. Washington, DC: Congressional Research Service, August 2, 2019.

———. *U.S. Strategic Nuclear Forces: Background, Developments, and Issues*. Washington, DC: Congressional Research Service, December 14, 2021.

_______. *Russia's Nuclear Weapons: Doctrine, Forces, and Modernization*. Washington DC: Congressional Research Service, April 21, 2022.

_______. *Nuclear Arms Control after the Biden-Putin Summit*. Washington DC: Congressional Research Service, February 28, 2022.

_______. *Nuclear-Armed Sea-Launched Cruise Missile (SLCM-N)*. Washington DC: Congressional Research Service, April 25, 2022.

Zhao, Tong. "China's Silence on Nuclear Arms Buildup Fuels Speculation on Motives." *Bulletin of the Atomic Scientists*. November 12, 2021.

Dennis Evans is the Quality Manager in the National Security Analysis Department (NSAD) at the Johns Hopkins University Applied Physics Laboratory (JHU/APL). Before joining JHU/APL in June 2013, he worked for DOD from 1982 through May 2013. For the last 19 years of his government career, he served in the Office of the Secretary of Defense, Cost Assessment and Program Evaluation (OSD CAPE). He worked for the U.S. Army National Ground Intelligence Center from 1982 through 1994. He received a Meritorious Executive Presidential Rank Award in 2010. He has a PhD in physics from the University of Virginia.

Brian Ellison runs the Strategy and Organizational Analysis section in NSAD. Before joining JHU/APL in 2016, he worked for 10 years at the Center for Naval Analyses, where he served in a range of Navy and Marine Corps field assignments working directly for flag and general officers, including Commander Carrier Strike Group Three, Commander Fleet Forces Command, and Marine Corps Forces, Pacific. His research focuses on Chinese strategic affairs, national security space, and intelligence capabilities. He received his PhD in War Studies from King's College London.

Matthew Lytwyn is the Program Manager for Policy and Strategy in NSAD, where he leads a program focused on shaping strategic decisions through technology-informed policy and threat analysis. He previously served as a Senior Advisor in the Office of the Secretary of Defense, a Senior Policy Analyst supporting multiple DOD and intelligence community customers, and a design engineer in the aerospace industry. He has expertise in defense strategy, nuclear deterrence, cyber, space, defense budgeting, science and technology policy, and analytic war-gaming techniques. He holds an MS in Defense and Strategic Studies from Missouri State University.

Jonathan Schwalbe is the Program Area Manager for Strategic Hypersonic Rapid Development in the Force Projection Sector of JHU/APL. His work has been primarily in the areas of strategic systems, nuclear weapons, hypersonic weapons, and deterrence. Before joining JHU/APL in 2013, he was a member of the senior staff at the MITRE Corporation and a national research council postdoctoral fellow in the Materials Science and Engineering Laboratory at the National Institute of Standards and Technology. He has a PhD in applied mathematics from Northwestern University.