



James M. Acton
Thomas D. MacDonald
Pranay Vaddi

REIMAGINING NUCLEAR ARMS CONTROL

A Comprehensive Approach



CARNEGIE
ENDOWMENT FOR
INTERNATIONAL PEACE

James M. Acton
Thomas D. MacDonald
Pranay Vaddi*

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* Until May 2021

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Carnegie Endowment for International Peace
Publications Department
1779 Massachusetts Avenue NW
Washington, DC 20036
P: + 1 202 483 7600
F: + 1 202 483 1840
CarnegieEndowment.org

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ABOUT THE AUTHORS

JAMES M. ACTON holds the Jessica T. Mathews Chair and is co-director of the Nuclear Policy Program at the Carnegie Endowment for International Peace.

THOMAS D. MACDONALD is a fellow in the Nuclear Policy Program at the Carnegie Endowment for International Peace. He holds a PhD in nuclear science and engineering from MIT.

PRANAY VADDI was a fellow in the Nuclear Policy Program at the Carnegie Endowment for International Peace, having formerly worked at the U.S. Department of State on arms control, treaty compliance, verification, nuclear deterrence, and other issues. He returned to the State Department in May 2021.

Matthew Harries contributed to chapter 9.

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ABBREVIATIONS

| | |
|------------------|---|
| C3I | command, control, communication, and intelligence |
| EODF | externally observable distinguishing feature |
| EPAA | European Phased Adaptive Approach |
| HEU | highly enriched uranium |
| HIMARS | High Mobility Artillery Rocket System |
| IAEA | International Atomic Energy Agency |
| ICBM | intercontinental ballistic missile |
| INF | Intermediate-Range Nuclear Forces (Treaty) |
| ITU | International Telecommunication Union |
| NATO | North Atlantic Treaty Organization |
| NEW START | New Strategic Arms Reduction Treaty |
| NSNW | nonstrategic nuclear weapon |
| NTM | national technical means |
| SALT | Strategic Arms Limitation Talks |
| SLBGM | sea-launched boost-glide missile |
| SLBM | sea-launched ballistic missile |
| SLCM | sea-launched cruise missile |
| SM-3 | Standard Missile-3 |

| | |
|--------------|---|
| SSBN | nuclear-powered ballistic missile submarine |
| SSGN | SSBN converted to carry cruise missiles |
| START | Strategic Arms Reduction Treaty |
| UID | unique identifier |

PREFACE

IN JANUARY 2020, the Nuclear Policy Program at the Carnegie Endowment for International Peace initiated a project to define a more promising future for arms control. We aim to mitigate acute nuclear risks by developing practical, concrete, and innovative ideas for interstate cooperation. In particular, we seek to catalyze the restart of U.S.-Russian risk-reduction efforts and to productively engage third parties, especially China.

In December 2020, we published a working paper containing five near-term politically binding proposals for reducing the risks of arms racing and inadvertent escalation.¹ After soliciting and receiving valuable feedback, we revised these proposals and are republishing them here—in our final report—along with one additional near-term measure and three ambitious, longer-term concepts. We welcome critiques on all these proposals from officials and experts in China, Russia, and the United States and its allies, as well as from other states. After all, because the consequences of a U.S.-Chinese or a U.S.-Russian nuclear war would be global, every state has an interest in reducing its likelihood.

SUMMARY

THE GOVERNMENTS of China, Russia, and the United States all express support for arms control. They disagree profoundly, however, about its purposes and preconditions. To try to find common ground, this report presents nine detailed practical measures that—implemented individually or as part of a package—would help address each state’s specific security concerns and the shared dangers of arms racing and inadvertent escalation.

Growing Nuclear Dangers

A renewed U.S.-Russian nuclear arms race, which has been largely qualitative so far but could soon turn quantitative, is underway. To compensate for perceived conventional inferiority, Russia maintains a much larger force of nonstrategic nuclear weapons (NSNWs) than the United States does, is fielding new systems, and may be increasing its overall number of nonstrategic warheads. In response, the United States is developing and deploying its own new types of NSNWs. (Russia and the United States generally use the term “strategic” to describe nuclear weapons with sufficient range to reach the other’s homeland from deployment locations in the possessor’s homeland or, in the case of sea-launched ballistic missiles, from firing locations well away from the other’s coast.)

At the strategic level, Russia believes that the United States is seeking capabilities—including high-precision conventional weapons and ballistic missile defenses—to undermine its nuclear deterrent. Moscow’s response has included the development and deployment of various new kinds of strategic weapons. The 2010 New Strategic Arms Reduction Treaty

(New START) helps to manage this competition by limiting all currently deployed U.S. and Russian strategic weapons, though it will expire in 2026.

Like Russia, China believes that the United States seeks to undermine its nuclear deterrent. As a result, Beijing is improving and expanding its long-range nuclear forces without giving any indication of its intended endpoint. Separately, it is also modernizing and enlarging its force of regional missiles, including dual-use weapons, in a likely effort to acquire more credible options for limited nuclear use. (Dual-use weapons can accommodate a nuclear or nonnuclear warhead.)

The vulnerability of nuclear C3I systems creates the possibility that Chinese or Russian operations against the United States could also lead to inadvertent escalation.

In a deep crisis or a conventional conflict between the United States and China or Russia, Chinese and Russian concerns about force vulnerability could spark inadvertent escalation. This risk is increasing because of the growing entanglement between the nuclear and nonnuclear domains. Such entanglement includes nonnuclear threats

to nuclear forces and their command, control, communication, and intelligence (C3I) systems and a reliance on dual-use C3I capabilities (that is, C3I capabilities that support nuclear and nonnuclear operations). Indeed, the vulnerability of nuclear C3I systems creates the possibility that Chinese or Russian operations against the United States could also lead to inadvertent escalation.

Unilateral responses to these dangers typically involve trade-offs between different escalation risks. For example, China's development of a strategic early-warning system that could enable it to launch its nuclear forces before they were destroyed in an incoming attack—thus enhancing their survivability—also creates the danger that it might mischaracterize a U.S. missile test as an attack.

The Purpose and Politics of Arms Control

Arms control—a term used here in its broad, original sense to mean “all the forms of military cooperation between potential adversaries” intended to improve mutual security—offers a proven and potentially powerful approach to managing nuclear risks. A first step is for Russia and the United States to commence negotiations toward a follow-on to New START. To avoid the overload and potential collapse of these negotiations, the scope of a New START follow-on should be limited to strategic offensive arms. As such, it could not manage every critical risk. Its focus on strategic arms would preclude the inclusion of Russia's and the United States' NSNWs. As a bilateral agreement, it would not regulate any Chinese capabilities and would also therefore be the wrong forum to manage the danger of

misidentifying a missile test as an attack. And because its scope would be restricted to offensive arms, it would do nothing to address Chinese and Russian concerns about ballistic missile defense and not enough to manage threats to nuclear C3I capabilities.

This report offers nine proposals—six near-term politically binding transparency and confidence-building measures and three more ambitious treaty concepts—that would help address these lacunae. These proposals would also help all three states—especially Russia and the United States—demonstrate commitment to their disarmament obligations and hence bolster the nonproliferation regime.

While each proposal raises some unique difficulties, a few implementation challenges would be common to many of them. Russia and the United States already have a dedicated channel for exchanging arms control notifications. China and the United States (and possibly China and Russia) would have to create one. In doing so, Beijing would be tacitly acknowledging the potential value of transparency—a step that it has not yet taken. Separately, a number of these proposals would require inspections on the territory of U.S. allies. While such inspections could be politically sensitive, the 1987 Intermediate-Range Nuclear Forces (INF) Treaty provides a clear precedent.

Some proposals would provide concrete benefits to all participants, while others would address the particular concerns of one state and therefore need to be negotiated as part of a mutually beneficial package.

China is the most skeptical of arms control and has recently emphasized its lack of interest in negotiations over nuclear limitations. However, it has failed to indicate whether it believes that its security could be enhanced by other forms of arms control and should now consider what concessions it would require from Washington in return for addressing U.S. concerns.

The United States is concerned about Russia's habit of violating arms control agreements, while Russia is concerned about the United States' habit of abrogating them. However, they are moving closer on the question of format. The United States is generally supportive of politically binding transparency and confidence-building measures. Russia, which has traditionally been skeptical of them, has recently shown more interest. The hybrid approach advocated here—which starts with a treaty that constrains strategic offensive arms implemented alongside separate transparency and confidence-building measures—offers the most practical and plausible way forward. Moreover, politically binding agreements can facilitate the development of legally binding ones.

Six Near-Term, Politically Binding Measures

The following six proposals are intended to quickly reduce the risks of arms racing and inadvertent escalation through politically binding agreements:

- A U.S.-Russian data exchange for sea-launched cruise missiles (SLCMs) and non-nuclear sea-launched boost-glide missiles (SLBGMs)
- A U.S.-Russian transparency regime for empty actual or suspected warhead storage facilities
- A U.S.-Russian confidence-building regime for European Aegis Ashore ballistic missile defense installations
- A U.S.-Chinese fissile material cutoff and transparency regime
- A trilateral launch notification agreement for ballistic missiles, missile defense tests, and space launches
- A trilateral agreement to establish keep-out zones around high-altitude satellites

The first three proposals, which involve Russia and the United States, aim to manage capabilities that cannot realistically be limited in their next bilateral treaty. The other three aim to engage China with the objectives of heading off a Chinese-U.S. arms race, reducing the danger of escalation as the result of a test or space launch, and protecting the survivability of key nuclear C3I assets.

First, Russia and the United States should, twice a year, exchange confidential declarations of the number of deployed nuclear-armed SLCMs, nonnuclear SLCMs, and nonnuclear SLBGMs (disaggregated by two range categories). Because of their potentially long ranges and high accuracies, SLCMs and, in the future, SLBGMs could drive arms racing and crisis instability. These dangers could be heightened if Russia or the United States overestimates the other's current or future deployments. Because limiting SLCMs or SLBGMs in a follow-on to New START would present insurmountable challenges—with the sole exception of making nuclear-armed SLBGMs accountable—transparency is a more practical way forward. Any security risks associated with this exchange should be minimal because it would not reveal a capability that was previously unknown to the other state or the precise mix of weapon types deployed—let alone the armaments on any particular ship.

Second, Russia and the United States should agree, on a politically binding basis, to reciprocal inspections of two to five pairs of empty actual or suspected warhead storage facilities to demonstrate that they do not contain nuclear warheads (here “empty” connotes the absence of all nuclear warheads, regardless of type). Ambiguity around the location of NSNWs creates serious risks. The possible presence of nuclear warheads in the Russian enclave of Kaliningrad, for example, exacerbates tensions—potentially unnecessarily

if, in fact, none are present. Moreover, in a conventional conflict, ambiguity could prove escalatory by leading to unnecessary attacks on storage facilities in an effort to forestall nuclear use. Inspections of empty facilities could help to reduce these risks.

Facilities would be selected on the basis of mutual consent, including from the host state for a facility located on the territory of the North Atlantic Treaty Organization (NATO) outside of the United States. Following facility selection, Russia and the United States would exchange baseline information, including site diagrams, and negotiate inspection boundaries.

Inspections should occur within sixty days of site selection. Following preliminary inspection procedures, the duration of the facility inspection should be limited to twelve hours. During that period, the inspection team should be given access first to any vehicles designated for inspection and then to any weapon storage containers and rooms that it selects in whatever order it chooses. The host state should have the right to shroud, in advance of the inspection, any items other than warhead storage containers that it deems sensitive. The inspection team should have the right to request the opening of any warhead storage container to verify that it does not contain a nuclear warhead. It should also have the right to employ radiation detection equipment to confirm that any shrouded objects, storage containers for nonnuclear munitions, and other objects do not contain nuclear material.

The technical challenges associated with this proposal appear manageable. From a political perspective, this proposal would not require negotiations over limits on NSNWs, thus respecting a Russian redline, and would build experience and confidence in inspecting warhead storage facilities, thus advancing the U.S. goal of a more comprehensive treaty. Because facilities must be selected by mutual consent, the host state could always veto an inspection request that presented insurmountable difficulties. This veto power represents an important safeguard—though if it were used too often, the proposed agreement would likely fall apart amid reciprocal accusations of bad faith.

Third, Russia and the United States should agree to a package of measures on European Aegis Ashore ballistic missile defense installations:

- Russia should, at the invitation of the United States, observe one flight test of a Standard Missile-3 (SM-3) Block IB interceptor and one of an SM-3 Block IIA interceptor in order to measure, with its own equipment, each interceptor's burnout speed (the maximum speed, which is reached immediately after a rocket's motors have cut off or burnt out).
- The United States should commit to (1) notifying Russia in advance of the first European deployment of any type of missile defense interceptor with a burnout speed greater than 3 kilometers per second (1.9 miles per second) that is not cur-

rently deployed there and (2) inviting Russia to observe, at least sixty days prior to the interceptor's first deployment in Europe, a flight test in order to measure the interceptor's burnout speed.

- The United States should reaffirm to Russia the exclusively defensive purpose of European Aegis Ashore installations and commit to refraining from (1) loading offensive missiles into European Aegis Ashore launchers and (2) modifying such launchers so they become capable of launching offensive missiles.

Russia is concerned that the United States' deployment of SM-3 interceptors in Europe to defend against Iranian ballistic missiles may threaten its ability to target the United States with intercontinental ballistic missiles (ICBMs). Moreover, the launchers for these interceptors are adapted from the U.S. Navy's MK-41 Vertical Launching System, which is used on ships equipped with the Aegis air and missile defense system to launch SLCMs and other missiles as well as SM-3s. The possibility that so-called Aegis Ashore launchers could also be used to fire offensive missiles, particularly cruise missiles—in spite of U.S. statements to the contrary—is a second concern for Moscow.

These concerns could motivate Moscow to attack Aegis Ashore installations preemptively in a crisis or conflict. They also complicate the development of arms control agreements—including measures to manage the new kinds of strategic weapons that Russia is developing to penetrate U.S. missile defenses. These risks could be reduced by increasing Russia's confidence in the capabilities of Aegis Ashore launchers.

Russia could monitor U.S. interceptor flight tests by positioning its missile range instrumentation ship on the high seas near the U.S. test site in Hawaii. The approach to verifying the exclusively defensive nature of Aegis Ashore installations would depend on whether Russia and the United States could jointly identify externally observable distinguishing features between such installations and their sea-based equivalents that would preclude the former from launching offensive missiles. If they could, verification would be based on national technical means (NTM) or inspections of external features. If not, the United States could permit Russian inspectors to select and view the inside of an agreed number of Aegis Ashore launchers to check that they are loaded with missile defense interceptors. Any form of on-site access would require the consent of the host state.

U.S. critics would probably argue that disclosing burnout speeds to Russia could compromise national security. This information, however, would not meaningfully assist Russia (or any third party to which Russia disclosed this information) to defeat U.S. defenses.

Russia's newfound willingness to consider politically binding confidence-building measures presents an opening for this proposal. To improve the prospects for progress, the administration of U.S. President Joe Biden should frame this proposal as the first step of a long-

term process to address a wider range of concerns that could potentially include the development of legally binding instruments.

Fourth, China and the United States should declare a joint politically binding cutoff in the production of weapon-usable fissile material. If China is unwilling to agree to a complete cutoff because it is still producing or plans to produce fissile material for civil purposes, it should agree to a cutoff in production for military purposes and to place all newly produced highly enriched uranium and separated plutonium under International Atomic Energy Agency (IAEA) safeguards. The two states should also commit to talks about mutual confidence building and to exchange confidential declarations about their stockpiles of weapon-usable fissile material.

There is broad consensus within the U.S. national security community about the importance of engaging China in arms control—not least to prevent China from challenging the United States in warhead numbers. Washington, however, cannot force Beijing to negotiate. Instead, if the United States is to have any chance of engaging China, it will have to craft proposals that mitigate Chinese concerns about transparency, while also identifying suitably valuable American concessions that could form part of a mutually beneficial quid pro quo. Because implementing this proposed measure would reveal only an approximate maximum size for China’s nuclear arsenal and nothing about weapon locations, it would help manage Chinese concerns about transparency.

The United States unilaterally ceased the production of fissile material for any purpose, civil or military, almost thirty years ago and has no plans to restart it. There are widespread but unconfirmed reports that China has ended the production of fissile material for military purposes, though the country has ambitious plans to develop a civil reprocessing program. The U.S. Defense Intelligence Agency assesses that China’s extant fissile material stockpile is not large enough for China to challenge the United States in warhead numbers. A credible cutoff in military fissile material production should therefore be sufficient to address U.S. concerns, so long as China places any newly produced civil fissile material under IAEA safeguards.

After declaring a cutoff, China and the United States should exchange confidential declarations about their stockpiles of weapon-usable fissile material and discuss any compliance concerns they might have, with the aim of developing targeted verification measures.

In verifying a cutoff, the primary challenge would be confirming the nonproduction of highly enriched uranium at enrichment facilities—which could require physical access. To be politically palatable, reciprocity would be required. By contrast, the comprehensive verification of stockpile declarations would be functionally impossible; ultimately, China and the United States would have to decide whether or not they were better off receiving additional information, even if they could not verify it.

This proposal would benefit the United States, which has an excess of fissile material, more than China, which probably wants to retain the option to produce more. Nonetheless, Beijing has three potential motivations to explore this proposal. First, it could be adopted as part of a mutually beneficial package. A politically binding agreement not to test or deploy space-based missile defenses could be a suitable quid pro quo. Second, the proposal would help China gain deeper insight into the U.S. fissile material stockpile. Third, it would presumably be more acceptable to China than the United States' preferred alternative of binding limits on nuclear forces.

Fifth, China, Russia, and the United States should agree to notify one another of (1) all space launches, (2) all test launches of ballistic or boost-glide missiles, and (3) all test launches of missile defense interceptors and of target missiles (subject, in each case, to defined conditions). If mistaken for an attack, a ballistic missile test, missile defense test, or space launch could spark escalation. Similarly, if preparations for a test launch were mistaken as preparations for an attack, they could invite preemption. While these risks may be low in peacetime, they could rise significantly during times of heightened tensions and, because of technological developments, could soon arise in a U.S.-Chinese crisis as well as a U.S.-Russian one.

Notifications before test or space launches can help reduce these risks; indeed, U.S.-Russian and Chinese-Russian notification agreements are in place. The existing regime has notable gaps, however. China and the United States have not agreed to exchange any launch notifications. The range thresholds that trigger notification requirements are too large. And, no state has committed to providing notifications about tests of boost-glide missiles, missile defense tests, or sub-orbital space launches.

Compared to other concepts for trilateral arms control, the political obstacles facing this proposal are small—though three challenges that are significant in absolute terms would have to be overcome. First, both China and the United States are more concerned about deliberate aggression than they are about inadvertent escalation, though both have recognized the possibility that escalation might not be deliberate. Second, they may disagree about what steps, if any, should follow this proposal—but this should not prevent them from supporting it if they believe it would enhance their security. Finally, all three states may be concerned that launch notifications could cue additional espionage activities to monitor launches. Such warning, however, would not significantly enhance the effectiveness of the intelligence-collection capabilities that each state already has or is developing.

Sixth, China, Russia, and the United States should make a joint political commitment to establish keep-out zones around their high-altitude satellites—that is, each should commit to maintain minimum separation distances between its satellites and the

satellites in high-altitude orbits that belong to other participants. Military communication and early-warning satellites in high-altitude orbits play critical roles in nuclear C3I systems. A repositioning operation that brought a satellite into proximity with one involved in nuclear operations could be misconstrued as preparation for an attack against the latter. Moreover, many satellites involved in nuclear operations are dual-use. As a result, in a conventional conflict, they might be attacked in an attempt to disrupt nonnuclear operations being conducted by their possessor. Such inadvertent threats to, and attacks on, space-based nuclear C3I capabilities would risk being interpreted as preparations for nuclear war—potentially sparking catastrophic escalation.

Keep-out zones could reduce the threat posed by co-orbital anti-satellite weapons to high-altitude satellites in two key ways, even while recognizing that such zones could not physically prevent attacks in a conflict. First, they would mitigate the danger of unintended threats to satellites resulting from nonhostile repositioning operations. Second, even if one participant decided to attack another's satellites, keep-out zones could buy time.

To ease implementation, repositioning operations that led one satellite to enter another's keep-out zone would be permitted—subject to various rules such as providing advance notification of the maneuver. Moreover, only the satellites declared by each participant would be afforded the protection of keep-out zones.

Participants would verify compliance with this proposed measure by using their own space situational awareness capabilities. The United States is likely already capable of effective verification. It is unclear whether Russia and China are too—though, if not, they are probably on a trajectory to acquire the necessary capabilities.

One key political challenge is that China and Russia appear to want the ability to hold U.S. satellites in high-altitude orbits at risk. However, as they are investing heavily in their own high-altitude military satellites, including for nuclear C3I, they may be interested in this proposal.

Three Longer-Term, Legally Binding Measures

Over the longer term, bilateral and trilateral treaties could be negotiated to build a more durable and robust risk-reduction architecture. Three such agreements, with varying levels of ambition, are proposed here:

- A trilateral treaty to prohibit the development and deployment of space-based missile defenses
- A trilateral treaty to limit ground-based missile launchers, sea-launched ballistic missile (SLBM) launchers, and bombers
- A U.S.-Russian limit on all nuclear warheads

First, China, Russia, and the United States should conclude a treaty prohibiting the testing or deployment of space-based missile defense weapons. Space-based missile defenses are capable, at least in theory, of addressing some key weaknesses of terrestrial missile defense systems. Russian and Chinese concerns about space-based defenses contribute to arms racing and exacerbate escalation risks, while complicating the development of agreements to manage these dangers. However, the development of space-based missile defenses presents daunting technical challenges and carries potentially exorbitant costs; for these reasons, the United States is unlikely to ever deploy a meaningful capability.

A trilateral prohibition on the testing and deployment of any space-based weapon designed to counter ballistic or boost-glide missiles would apply to both kinetic and nonkinetic weapons but would not affect the deployment of space-based sensors to detect missile launches or track missiles during flight. The prohibition would be verified through NTM, with efforts primarily focused on assessing compliance with the ban on testing. To gain a meaningful operational capability, a lengthy testing campaign would be needed. Such a campaign would be difficult to conceal against multiple intelligence-collection techniques, even if a state were sometimes successful in hiding individual tests.

Russia and China would likely support this proposal. The primary political impediment to its conclusion would be domestic resistance in the United States, stemming from an understandable though unattainable desire to develop a comprehensive defense against ballistic missile attack. That said, limitations on space-based interceptors, whose development costs would be prohibitive, may be somewhat more palatable for the United States than limitations on ground-based missile defenses. Furthermore, if China and Russia want a prohibition of space-based missile defenses, they will have to make significant concrete concessions to the United States in return.

Second, China, Russia, and the United States should conclude a treaty that would limit each party to equal total numbers of launchers for ground-launched cruise missiles, ground-launched ballistic missiles, and ground-launched boost-glide missiles with ranges over 475 kilometers (295 miles); SLBM launchers; and bombers with ranges greater than 2,000 kilometers (1,200 miles). Such limits could help prevent arms racing and mitigate escalation risks by curtailing the threat posed to national and military leaders and to nuclear forces and their enabling capabilities.

This agreement would limit launchers, rather than smaller items like warheads or missiles, to reduce verification difficulties significantly. Ground-based launchers would be accountable if used to launch missiles with a range in excess of 475 kilometers—and not 500 kilometers (310 miles) as under the INF Treaty—to bypass the controversy over the range of

the SSC-8, a Russian ground-launched cruise missile that the United States claims, almost certainly correctly, was developed in violation of that treaty. In a major concession to China and Russia, the United States would agree that, for the purposes of treaty implementation, its Aegis Ashore launchers met the definition for launchers of ground-launched cruise missiles and were thus accountable. In a major reciprocal concession to Washington, Beijing and Moscow would agree that the treaty should not constrain SLCM or SLBGM launchers.

It appears that China, Russia, and the United States currently possess roughly equal numbers of accountable launchers and accountable bombers (though there are large uncertainties in the estimates for China and particularly Russia), and it seems possible this rough equality will persist. To make the agreement more politically palatable, the chosen central limit should be slightly higher than any state's arsenal of accountable launchers and accountable bombers at the time of entry into force.

To facilitate verification, China, Russia, and the United States should exchange baseline information, comprehensive semiannual updates, and regular notifications about accountable launchers and accountable bombers. The three parties should be able to use NTM, including satellite imagery, to verify numbers of accountable bombers, fixed accountable ground-based launchers (silos), and SLBM launchers. To facilitate verification, they should agree not to interfere with one another's NTM.

On-site inspections would likely be needed to verify mobile accountable ground-based launchers. These inspections would be modeled on New START's provisions for inspections of mobile ICBM launchers, though would be less intrusive because there would be no requirement to display missile front sections, revealing the attached reentry vehicles and other sensitive objects.

The proposed treaty is built on Russia's and the United States' extensive experience in implementing limits on heavy bombers and various types of missile launchers pursuant to past arms control agreements. That experience suggests that verification is feasible and that the risk of a party's retaining a militarily significant number of undeclared accountable launchers—mobile ground-based launchers, in particular—should be manageable.

There would be many political barriers to reaching an agreement, including Chinese concerns about a radical increase in transparency. Most acutely, many U.S. officials and analysts would likely argue that the United States should build up its force of regional missiles before seeking limits through arms control. One problem with this approach is that deploying mobile ground-launched missiles to allied territory, where they would be militarily useful, would likely prove politically fraught. Moreover, while some buildup may be unavoidable, it risks stimulating arms racing. The question that decisionmakers in Washington—and Beijing and Moscow, for that matter—must ask themselves is how the risks of trying to break away from today's rough equality compare to the risks of living with it.

Third, Russia and the United States should work toward a treaty that would limit each state's total number of nuclear warheads—irrespective of their type, location, or deployment status and whether or not they are awaiting dismantlement. New START limits the approximately 2,700 nuclear warheads deployed on ICBMs and SLBMs—less than 25 percent of Russia and the United States' combined total inventory of warheads. No other warheads—those in storage, those being transported, and those that have been retired and are awaiting dismantlement—are even indirectly accountable. Given the concerns of the United States and its allies over Russia's large force of nonstrategic nuclear warheads, there is considerable interest across the U.S. political spectrum in a warhead limit. Russia, by contrast, has little interest in such a treaty. To have any chance of Russia's agreeing to it, the United States would have to offer a very significant concession in return, such as limits on missile defense.

The technical challenges associated with verifying a warhead limit would likely preclude agreement today. Verification would involve data exchanges and notifications (which would be relatively straightforward) and on-site inspections (which would be much more challenging), supplemented by each state's NTM capabilities.

A treaty would not need to contain specific verification provisions for warheads deployed on ICBMs, SLBMs, and heavy bombers, which are accountable under New START and should continue to be under a successor. However, the agreement would require inspections of warhead storage facilities. All warheads in transport would be exempt from inspections.

Inspections would face a fundamental difficulty: The classification rules surrounding warheads would prevent inspectors from viewing them directly or conducting any measurements that could reveal sensitive design information. Therefore, verification would largely focus on warhead storage containers on the assumption that, to prevent nuclear accidents, Russian and U.S. warheads are always kept in such containers when not attached to strategic delivery vehicles.

In many circumstances, classification rules would not impede effective verification since the host state would generally gain no advantage by claiming that an empty storage container held a warhead. Prior to warhead dismantlement, however, such a claim could enable cheating (by subsequently “dismantling” those nonexistent warheads, the state could retain more warheads than it had declared). It therefore would be necessary to verify that an object declared to be a warhead awaiting dismantlement really was an actual warhead. This process would be challenging for two reasons: first, it would be necessary to define what a warhead is in terms of measurable criteria, and second, the unauthorized disclosure of classified information during the measurement process would need to be prevented.

Technological solutions to these problems have been proposed and developed. A warhead could be defined in terms of certain attributes or its similarity to a template, and a so-called information barrier could sit between the detection equipment and the inspector to provide an approved output. However, these solutions are far from being ready to use in treaty verification. Moreover, given the exceptional sensitivity of assembly/disassembly facilities, which were not intended to be transparent, designing and implementing a credible verification system could prove challenging.

Overcoming these challenges requires more individual and joint research. Individual efforts should include restarting national research programs on warhead-level arms control. Russia and the United States should also undertake the following cooperative efforts, which would realistically require some improvement in their political relationship:

- Restart joint research into warhead verification
- Start joint studies into inspections at warhead storage facilities and commit to extending such studies to include assembly/disassembly facilities in the future
- Negotiate reciprocal inspections to verify the absence of nuclear warheads at empty actual or suspected warhead storage facilities
- Negotiate a warhead information exchange for implementation on a politically binding basis
- Consider whether New START's replacement should limit all warheads located on ICBM, SLBM, and heavy bomber bases, whether deployed or in storage

Prospects

Although these proposals vary significantly in their level of ambition, none likely present any currently insurmountable technical barriers—except for the treaty to limit all warheads for which significant additional preparatory work would be required. Moreover, implementing any of them would help to reduce nuclear dangers. We therefore urge Beijing, Moscow, and Washington to adopt them.

While calling for progress, however, we recognize that politics create real roadblocks, especially to the more ambitious proposals. The pace of progress on arms control will be constrained by fraught international relationships and divisive internal politics that create incentives for leaders not to cooperate with rivals. Indeed, generating the necessary political will to turn these nine proposals into reality will be challenging. There may be no simple fix, but history demonstrates that political barriers are not immutable. While it is impossible to predict when opportunities for arms control will arise, China, Russia, and the United

States and NATO should consider and refine proposals now to enable rapid progress when political conditions are favorable.

Each state should ask itself whether its interests would be better served by a broader conception of its security goals—one that encompasses the prevention of arms racing and the mitigation of inadvertent escalation risks as well as the development of effective deterrence capabilities. Arms control can be a powerful tool for navigating the trade-offs in pursuing these objectives and hence for better managing the risks inherent to enhancing security through threats of catastrophic destruction.

INTRODUCTION

THE GOVERNMENTS of China, Russia, and the United States all express support for arms control.² However, they disagree profoundly about its purposes and preconditions. At the root of this disagreement are important and growing differences between the threats that concern the United States and those that concern China and Russia. Having largely failed to bridge this divide, these states are now responding to their perceived threat environments in ways that drive nuclear arms racing and thus exacerbate interstate tensions. Should these tensions spill over into war, their responses could spark inadvertent escalation and nuclear use. Arms control could help to manage these risks and enhance the security of all three states—if they can find a mutually acceptable way forward.

The New Nuclear Arms Race

To date, the renewed U.S.-Russian nuclear arms race has been largely qualitative but could soon turn quantitative. One driver is an imbalance in conventional forces. Many of Russia's neighbors, including Eastern European members of the North Atlantic Treaty Organization (NATO), are concerned about being coerced by Moscow through either nonmilitary or military means. Moreover, because of Russia's conventional superiority around the Baltic region, Estonia, Latvia, and Lithuania also worry about a full-scale invasion. These concerns have led the United States to keep about 100 nonstrategic nuclear weapons (NSNWs)—out of a total of about 230 such weapons—deployed in Europe.³ (In unhelpful language inherited from the Cold War, Russia and the United States generally use the term “strategic” to describe nuclear weapons with sufficient range to reach the other's homeland from de-

ployment locations in the possessor's homeland or, in the case of sea-based weapons, from firing locations away from the other's coast.⁴)

Russia, meanwhile, views itself as conventionally inferior to NATO across Europe as a whole. It relies heavily on nuclear weapons—especially NSNWs—for deterring large-scale aggression. The U.S. Department of Defense assesses that Russia has “up to 2,000” non-strategic warheads and may be increasing that number.⁵ Moreover, Moscow is developing and deploying various new types of NSNWs, including, most controversially, the SSC-8—a dual-use ground-launched cruise missile that the United States assesses, almost certainly

Russia believes that the United States is seeking capabilities—particularly nonnuclear ones—to undermine its nuclear deterrent.

correctly, was developed in violation of the Intermediate-Range Nuclear Forces (INF) Treaty. (Dual-use weapons can accommodate a nuclear or nonnuclear warhead.)

Washington believes that these developments reflect a growing Russian willingness to threaten to use, or even to use, nuclear

weapons early in a conflict—particularly following an invasion of the Baltic states—in the hope of compelling the United States to stand down.⁶ Russian officials have strenuously denied that their nuclear doctrine embraces this concept, which is often called “escalate to de-escalate” in Western discourse.⁷ These denials have not assured Washington. Indeed, to correct the “mistaken Russian perception” that Moscow's advantage in NSNWs would provide it with “a coercive advantage,” the United States has deployed low-yield warheads on some Trident D5 sea-launched ballistic missiles (SLBMs) and has started to acquire a nuclear-armed sea-launched cruise missile (SLCM), though the administration of U.S. President Joe Biden may cancel this program.⁸ Meanwhile, the United States' withdrawal from the INF Treaty, ostensibly because of Russia's deployment of the SSC-8 cruise missile, has opened the door to a competition in medium- and intermediate-range ground-launched missiles (though only Russian weapons are likely to be nuclear-capable).

The U.S.-Russian competition is also playing out with strategic weapons. Russia believes that the United States is seeking capabilities—particularly nonnuclear ones—to undermine its nuclear deterrent. Moscow fears that, after the further development and deployment of both offensive and defensive systems, the United States could be in a position to launch nuclear or nonnuclear preemptive strikes on Russia's nuclear forces and then use ballistic missile defenses to mop up any surviving Russian weapons fired in retaliation. Stripped of its nuclear deterrent in this way, Moscow believes it would be left vulnerable to U.S. coercion.

Russia's defense spending suggests that these concerns are acute. In 2018, for example, Russian President Vladimir Putin announced the development of three new kinds of “exotic” strategic nuclear delivery systems as a way of preserving Russia's ability to defeat U.S. defenses.⁹ Russia has since deployed one of these systems—an intercontinental hypersonic

glider, Avangard. The other two—a nuclear-powered cruise missile, Burevestnik, and a nuclear-powered torpedo, Poseidon—remain under development.

The New Strategic Arms Reduction Treaty (New START) helps to manage this competition by limiting all currently deployed U.S. and Russian strategic weapons, including Avangard. Following its extension in early 2021, this treaty will remain in force until 2026. However, the prospects for negotiating a follow-on agreement are unclear. Without a strategic arms limitation agreement in place, the result could be a renewed numerical arms race in strategic weapons.

China is not a party to New START or any other agreement that limits its nuclear forces. Currently, those forces are significantly smaller than either Russia's or the United States'. The United States estimates that China's nuclear warheads number in the "the low-200s."¹⁰ By comparison, the United States has indicated that, as of September 2020, it possessed 3,750 nuclear warheads, while Russia has likely well in excess of 4,000.¹¹ However, China is steadily expanding its nuclear arsenal without giving any indication of its intended endpoint. The U.S. Department of Defense expects China to "at least double" its warhead stockpile over the next decade.¹²

Like Moscow, Beijing believes that the United States seeks to undermine its nuclear deterrent.¹³ The commander of U.S. Northern Command, which is responsible for homeland defense, has publicly assessed that China is "investing heavily to improve the survivability and penetrability of its nuclear forces in an effort to guarantee its ability to retaliate following a strategic first strike."¹⁴ To meet these objectives, Beijing is improving and expanding its long-range nuclear forces. Many of its programs are focused on ensuring that its nuclear forces will continue to have the ability to penetrate U.S. missile defenses for the indefinite future. Official U.S. sources, for example, have indicated that China has deployed intercontinental ballistic missiles (ICBMs) armed with multiple warheads and is "looking at" nuclear-powered cruise missiles and torpedoes.¹⁵ According to media reports, U.S. officials also believe that, in the summer of 2021, China conducted two tests of a novel nuclear-weapon delivery system that first enters orbit before releasing a hypersonic glider.¹⁶ To complicate any U.S. attempt to attack its nuclear forces preemptively, China is upgrading its mobile ground-based ICBM launchers, deploying six nuclear-powered ballistic missile submarines (SSBNs), and constructing at least 230 missile silos (and possibly many more), though it may not be intending to place an ICBM in every silo, at least initially.¹⁷ (Launchers are any device used to store and launch missiles. They include truck- and rail-based systems, silos, fixed above-ground systems, and launch tubes on submarines.)

Separately, China is also modernizing and expanding its force of regional missiles, including dual-use weapons.¹⁸ This development is probably motivated by the desire to acquire more credible options for limited nuclear use rather than concerns about force survivability.

Growing Escalation Dangers

In a deep crisis or a conventional conflict between the United States and China or Russia, the concerns about force vulnerability that drive arms racing could spark inadvertent escalation. Crisis instability is one potential danger.¹⁹ If the United States' adversary concluded that a U.S. attack on its nuclear forces was imminent, it might issue nuclear threats or engage in limited nuclear use to try to terrify Washington into backing off. If the adversary were Russia, then in extreme circumstances, it might even attack U.S. nuclear forces preemptively to try to protect itself (China's nuclear forces are currently too small to even attempt such an operation).

This risk of crisis instability is being exacerbated by the growing entanglement between the nuclear and nonnuclear domains.²⁰ For much of the Cold War, threats to nuclear weapons came largely from other nuclear weapons. Today, both China and Russia perceive a real and growing danger of preemptive nonnuclear attacks on their nuclear forces—including with cyber capabilities, cruise missiles, and, in the future, hypersonic boost-glide missiles—and of interception after the launch of those forces by nonnuclear missile defense interceptors.

The United States, by contrast, is much less concerned about the survivability of its nuclear forces. Entanglement, however, is also undermining the survivability of nuclear command, control, communication, and intelligence (C3I) capabilities—including the United States'—and creating new escalation risks. For early-warning and long-range communications especially, the U.S. nuclear C3I system relies on a relatively small number of impossible-to-hide assets in space and on the ground. They are becoming increasingly vulnerable to the improving anti-satellite and long-range conventional strike capabilities being acquired by China and Russia. The U.S. nuclear C3I system is almost certainly vulnerable to cyber attacks too (though it is more difficult to assess whether the risk of successful attacks is increasing or decreasing).²¹

To compound these vulnerabilities, many C3I assets—including ground-based radars and communication transmitters and early-warning and communication satellites—support both nuclear and nonnuclear operations. In a conventional conflict, an adversary might attack these assets to undermine the effectiveness of U.S. nonnuclear operations. However, such attacks could have the effect of degrading U.S. nuclear C3I systems. As a result, Washington might interpret them as the prelude to nuclear use and escalate the conflict in an attempt to coerce the adversary into backing down. In fact, the United States has explicitly threatened to resort to nuclear use should its nuclear C3I capabilities come under nonnuclear attack.²² (China and Russia are almost certainly concerned about the survivability of their nuclear C3I systems too. However, the extent to which China's system, in particular, depends on dual-use assets is less clear.)

Unilateral efforts to enhance the resilience and survivability of states' nuclear forces and their C3I systems can enhance security but typically involve trade-offs between differ-

ent escalation risks. For example, China is currently developing a strategic early-warning system that could enable it to launch its nuclear forces before they were destroyed in an incoming attack.²³ While a launch-under-attack capability could increase Beijing's confidence in the survivability of its nuclear forces, it could also lead to China's mischaracterizing, say, a U.S. missile test in the Pacific region as an attack—potentially catalyzing a nuclear response.

An Agenda for Cooperative Risk Reduction: Nine Practical Measures

Arms control offers a complementary, proven, and potentially powerful approach to managing the risks of both arms racing and inadvertent escalation and, more generally, to reducing the risk of conflict. The term “arms control” is used here in its broad, original sense to mean “all the forms of military cooperation between potential adversaries” intended to improve mutual security.²⁴ Such cooperation includes treaty-mandated limits on nuclear forces with intrusive verification and extends to confidence building, transparency, and behavioral norms.

A first step in reviving arms control is for Russia and the United States to commence negotiations toward a follow-on treaty to New START. Two authors of this report recently set out a detailed concept for such an agreement.²⁵ To avoid overloading negotiations and thus risking their collapse, the scope of a New START follow-on should be limited to strategic offensive arms, including new kinds of such weapons (nuclear and nonnuclear) developed since New START's entry into force. Such an agreement would help mitigate the acute dangers created by Russia's and the United States' possessing large and uniquely destructive forces of strategic nuclear weapons that threaten one another.

A bilateral treaty on strategic offensive arms could not manage all the risks outlined above, however. Its focus on strategic arms would preclude any limitation of Russia's and the United States' NSNWs. And as a bilateral agreement, it would not regulate any Chinese capabilities and would also, therefore, be the wrong forum to manage the danger of misidentifying a missile test as an attack. Further, because its scope would be restricted to offensive arms, it would do nothing to address Chinese and Russian concerns about ballistic missile defense and not enough to manage threats to nuclear C3I capabilities.

In the near term, politically binding transparency and confidence-building measures present the most promising means to start addressing these lacunae, not least because of the difficulties posed by treaty ratification procedures within the United States. Such measures should be negotiated alongside a New START follow-on and would both complement and enable it. This report proposes six such measures:

- A U.S.-Russian data exchange for SLCMs and nonnuclear sea-launched boost-glide missiles (SLBGMs)

- A U.S.-Russian transparency regime for empty actual or suspected warhead storage facilities
- A U.S.-Russian confidence-building regime for European Aegis Ashore ballistic missile defense installations
- A U.S.-Chinese fissile material cutoff and transparency regime
- A trilateral launch notification agreement for ballistic missiles, missile defense tests, and space launches
- A trilateral agreement to establish keep-out zones around high-altitude satellites

Over the longer term, bilateral and trilateral treaties could be negotiated to provide a more durable and robust risk-reduction architecture. Three such agreements, with varying levels of ambition, are proposed here:

- A trilateral treaty to prohibit the development and deployment of space-based missile defenses
- A trilateral treaty to limit ground-based missile launchers, SLBM launchers, and bombers
- A U.S.-Russian limit on all nuclear warheads

Although these proposals vary significantly in their level of ambition, none likely present any currently insurmountable technical barriers—except the treaty to limit all warheads for which significant additional intragovernmental preparatory work would be required. Moreover, implementing any of them would help reduce nuclear dangers. Therefore, in laying out these proposals, we generally urge Beijing, Moscow, and Washington to adopt them. While calling for progress, however, we recognize that politics create real roadblocks, especially to the more ambitious proposals. The pace of progress on arms control will be constrained by the overall state of the U.S.-Russian and U.S.-Chinese relationships, and, to a lesser extent, the Russian-Chinese relationship.

Cross-Cutting Implementation Issues

The proposals detailed here are intended to be practically useful for the officials who would be charged with negotiating them. While each proposal raises some unique difficulties, a few implementation challenges would be common to many of them. Determining a missile's range, largely a technical issue, could be difficult (see appendix A). Exchanging data and facilitating inspections on the territory of U.S. allies—technically more straightforward—could be politically contentious.

Most arms control regimes require a dedicated mechanism to exchange data. Normal diplomatic channels may occasionally suffice, but they are ill-suited to rapid exchanges, especially involving large quantities of information. For this reason, Russia and the United States agreed, in 1987, to each set up a Nuclear Risk Reduction Center to enable reliable and rapid communications, including arms control notifications (the United States has since renamed its center the National and Nuclear Risk Reduction Center). These centers provide Russia and the United States with an already established, dedicated communication channel that would be useful in implementing virtually all the proposals described in this report.

But the proposals including China would also require data exchanges, and it is unclear whether Beijing has a similar center or organization. It may have one to facilitate its current participation in other arms control regimes. Perhaps the most relevant such regime is a 2009 Russian-Chinese launch notification agreement (discussed further in chapter 5) that requires the parties to maintain a communication channel. However, there is no publicly available information on what Chinese entity is responsible for sending and receiving notifications, thus making it difficult to assess this channel's utility for other applications. Regardless, even if Beijing and Moscow have a dedicated communication channel suitable for exchanging arms control notifications, Beijing and Washington do not.

A U.S.-Chinese link and, if needed, an additional Russian-Chinese link would be useful in facilitating further cooperation both bilaterally and trilaterally. Although establishing the former channel would be straightforward from a technical perspective, the process would be plagued by politics. By agreeing to establish it, Beijing would be tacitly acknowledging the potential value of arms control and, in particular, of transparency—a step that, as discussed below, it has not yet taken.

Regarding inspections, a number of proposals would require them of specified kinds of U.S. military equipment located on the territory of its allies (and of any similar Chinese or Russian equipment deployed outside of their national territory in the future). While such inspections could be politically sensitive, the INF Treaty provides a clear precedent. Although it was negotiated bilaterally, this agreement permitted the Soviet Union and then Russia to conduct inspections at various bases in five NATO states. These inspections were facilitated through a separate agreement between the United States and those NATO states.²⁶ A similar approach, which would require close coordination between the United States and its allies, should be adopted here.²⁷

By agreeing to establish a communication channel, Beijing would be tacitly acknowledging the potential value of arms control and, in particular, of transparency—a step that it has not yet taken.

The Politics of Arms Control

U.S. priorities for arms control largely relate to China's and Russia's nuclear forces.²⁸ The Biden administration seeks to preserve the existing limits on Russia's strategic forces and extend them to capture Moscow's developmental exotic strategic nuclear weapons and its nonstrategic nuclear forces. Where China is concerned, the administration has identified risk reduction as its most immediate priority, while also seeking to prevent "unnecessary arms races"—which, in practice, means

It is becoming ever more difficult to craft individual arms control proposals that simultaneously further all three states' interests—at least as they define them—even if the obligations enshrined in each proposal are entirely reciprocal.

limiting the growth of China's nuclear forces.²⁹ By contrast, China and Russia are primarily worried about developments in U.S. nonnuclear technology—precision strike capabilities and missile defenses, in particular—which those states fear could undermine the survivability of their nuclear forces.

As a result of this divergence, it is becoming ever more difficult to craft individual arms control proposals that simultaneously further all three states' interests—at least as they define them—even if the obligations enshrined in each proposal are entirely reciprocal. Indeed, many of the proposals outlined in this report are intended to address the concerns of just one or two states.

One practical way to overcome this problem would be to negotiate over multiple proposals simultaneously. Even if no single measure were acceptable to all the parties concerned, a package deal, comprising two or more measures, could nonetheless be mutually beneficial. For example, Russia and the United States could agree to simultaneously implement one confidence-building measure focused on ballistic missile defense and another covering NSNWs. While such packages are suggested here, it is difficult to predict exactly which agreements may be within reach at any given time; therefore, success would depend on skillful diplomacy to take advantages of opportunities as they arise.

More generally, because of the potentially cataclysmic consequences of a nuclear war—which, because of radioactive fallout, climatic effects, and economic collapse, would be experienced by every state, including nonbelligerents—China, Russia, and the United States have a clear joint interest in avoiding inadvertent nuclear escalation, thereby creating much stronger shared interests than they often realize. Measures that reduced the likelihood of such escalation would create benefits for every participant, even if they did not address the concerns of every participant. In theory, this realization should leave Beijing, Moscow, and Washington more willing to address one another's concerns—though, as a practical matter, they are likely to find the logic of negotiating package deals more compelling.

Another consideration for all three states—but particularly Russia and the United States—is their commitment, under Article VI of the Nuclear Non-Proliferation Treaty, “to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament.” The proposals in this report would advance the goals of Article VI in various ways. Limits on fissile material production, warheads, and missiles are necessary steps toward a world without nuclear weapons, while inspections of storage facilities to verify the absence of nuclear warheads would be needed as part of any credible regime to verify the transition to such a world. In the meantime, many of these same proposals would help to curtail arms racing—as would enhanced transparency around ballistic missile defenses and sea-based missiles. Member states have also agreed that the purpose of Article VI can be advanced through “policies that could . . . lessen the danger of nuclear war.”³⁰ A number of proposals—including launch notifications and keep-out zones for high-altitude satellites—fall into this category. At a time when many non-nuclear-weapon states are deeply skeptical of the nuclear-weapon states’ willingness to live up to their disarmament commitments—and when there is little prospect of any major breakthrough in efforts to achieve a world without nuclear weapons—the proposals set out here offer a way to make visible progress on Article VI and thus bolster the non-proliferation regime.

Beyond the problem of finding enough shared interest to catalyze progress, China, Russia, and the United States also have their own specific concerns about arms control, even while they say they support it in principle. China is the most skeptical. It is not a party to any nuclear arms control agreement other than the 1968 Nuclear Non-Proliferation Treaty (though, like the United States, it has signed but not ratified the 1996 Comprehensive Nuclear-Test-Ban Treaty). Recently, Beijing has been very clear about its lack of interest in negotiations over nuclear limitations—at least until the United States makes deep reductions in its nuclear forces.³¹ Beijing has failed, however, to indicate whether it believes that China’s security could be enhanced by other forms of arms control—though Chinese scholars have expressed a general concern that greater transparency would risk undermining the survivability of its nuclear forces.

Yet the benefits and risks of transparency, as an abstract principle, are not at issue; the effects of specific proposals on Chinese security are. Indeed, China has previously participated in nonnuclear arms control with potentially hostile foreign powers when there have been clear benefits to doing so. For example, in the late 1990s, when Chinese-Russian relations were significantly worse than they are today, China negotiated a verified treaty that limits conventional weapons near its borders with Russia and three Central Asian republics.³² In that spirit, Chinese officials and analysts should consider what arms control measures related

China has previously participated in nonnuclear arms control with potentially hostile foreign powers when there have been clear benefits to doing so.

to nuclear weapons, missiles, and missile defenses would advance Chinese interests. They should then explore the trade-space with their U.S. counterparts—first in unofficial and then official dialogues—with the goal of developing mutually beneficial packages.³³

Russia and the United States, meanwhile, each have various concerns about engaging the other. In recent years, the United States has raised frequent and legitimate complaints about Russian compliance with various existing agreements and is therefore understandably hesitant to enter into new ones.³⁴ At the same time, Moscow points to the United States' withdrawal from a number of arms control and nonproliferation agreements over

In June 2021, Russian Deputy Foreign Minister Sergey Ryabkov indicated a clear interest in negotiating legally and politically binding instruments alongside one another.

the past two decades as a reason for skepticism about engaging Washington.³⁵ (Two of these withdrawals, from the 1972 Anti-Ballistic Missile Treaty and the 2015 Joint Comprehensive Plan of Action, were particularly damaging to U.S. credibility as Washington assessed that the Soviet Union and Iran, respectively, were complying with their commitments at the time it left the agreements.) Legally, abrogating obligations

is certainly preferable to violating them; politically, however, Russian concerns about entering into new agreements with the United States also are understandable (and shared by other countries too). None of these concerns can be addressed through the text of an agreement, yet they have not precluded cooperation where it has been clearly mutually beneficial—as most recently illustrated by the extension of New START.

One question that Moscow and Washington will have to address is whether agreements should be politically or legally binding. The United States is generally supportive of the principle of politically binding transparency and confidence-building measures—not least because they obviate the challenge of obtaining the Senate's advice and consent for treaty ratification—even if, in practice, Washington has sometimes shown a lack of willingness to elaborate or explore specific proposals. Russia, by contrast, often expresses skepticism about politically binding agreements, dismissing them as “verification for the sake of verification, transparency for the sake of transparency.”³⁶ It seeks the greater predictability that is supposed to come with legally binding agreements. Moreover, Russian officials privately argue that it is more politically difficult and time consuming for the United States to withdraw from treaties.³⁷

In practice, however, the benefits of treaties have not proven to be so marked. Given the fate of the Anti-Ballistic Missile Treaty, the INF Treaty, and the 1992 Open Skies Treaty, it is far from clear that a U.S. administration actually pays a greater political price for withdrawing from a treaty than from a politically binding agreement such as the Joint Comprehensive

Plan of Action. And, although treaties contain withdrawal timelines, the minimum notification periods are often quite short—typically just six months.

Moreover, Russia has sometimes shown flexibility and, despite its concerns, has accepted politically binding agreements. For example, in 1988, the Soviet Union and the United States conducted the Joint Verification Experiment, in which each state measured the yield of a nuclear test conducted by the other, pursuant to a politically binding agreement. More recently, in June 2021, Russian Deputy Foreign Minister Sergey Ryabkov indicated a clear interest in negotiating legally and politically binding instruments alongside one another, stating that Russia and the United States could “decide to adopt a package of interrelated arrangements and/or agreements *that might have different status if necessary*.”³⁸

The hybrid approach advocated here—which starts with a treaty that constrains strategic offensive arms and is implemented alongside transparency and confidence-building measures—is consistent with Ryabkov’s suggestion and offers the most practical and plausible way forward. Politically binding measures currently represent the only viable way to address issues that, for technical or political reasons, cannot be managed through treaties. Moreover, historically, politically binding agreements have facilitated the development of legally binding ones. For example, the Joint Verification Experiment facilitated the 1974 Threshold Test Ban Treaty’s entry into force in 1990. In this spirit, the development of politically binding confidence-building measures should be the start of a process, not the end of one.

CHAPTER 1

FILLING A LEGAL LACUNA: A U.S.-RUSSIAN DATA EXCHANGE FOR NONACCOUNTABLE MISSILES

MODERN SLCMS ARE HIGHLY capable. They are accurate, difficult to detect and track, and have sufficient ranges—approaching 3,000 kilometers (1,900 miles)—to reach targets deep within an adversary’s interior.³⁹ Both Russia and the United States deploy large forces of conventional SLCMs, creating escalation risks. Russia is concerned that U.S. weapons threaten its nuclear forces, particularly mobile ICBMs but also docked SSBNs, heavy bombers on the ground, and perhaps even silo-based ICBMs.⁴⁰ Meanwhile, Russian nonnuclear SLCMs threaten critical U.S. military assets, including ground-based C3I capabilities that support nuclear operations, and potentially national and military leadership.

The development of SLCMs can also feed arms racing. The United States is acquiring (for now, at least) a nuclear-armed SLCM in response to its concerns about Russian NSNWs, which include SLCMs. If deployed, this new U.S. missile will likely further exacerbate Moscow’s concerns about the survivability of its nuclear forces, potentially catalyzing a Russian response.

SLBGMs have not yet been deployed by either state. But if various technical challenges are overcome, these missiles could be as accurate as SLCMs, while traveling much faster and over potentially greater distances.⁴¹ As such, they could exacerbate both escalation risks and arms racing. The United States is currently developing nonnuclear SLBGMs.⁴² There is no public evidence of an equivalent Russian effort—though it would come as no surprise to learn that Moscow has initiated one. Russian SLBGMs would most likely be nuclear-armed or dual-use.

These dangers will be heightened if either Russia or the United States overestimates the other's current or future deployments of SLCMs or SLBGMs. This kind of threat inflation could result from the very real difficulties associated with estimating the current size of an adversary's sea-based missile force—let alone its future size.

Estimating current SLCM deployments is challenging because modern vertical launching systems can accommodate various types of missiles, including air and missile defense interceptors and anti-ship and anti-submarine weapons, in addition to land-attack SLCMs. As a result, surface ships (and perhaps submarines) may carry fewer SLCMs than the maximum possible in order to facilitate the deployment of other kinds of weapons. The United States faces the additional challenge of estimating how many of Russia's deployed SLCMs are nuclear-armed. Russia will face the same problem if the United States deploys nuclear-armed SLCMs of its own.

The challenges of estimating future deployments are even greater because states could change the number of SLCMs they deploy surreptitiously and relatively quickly. The probable deployment of nonnuclear SLBGMs, which will likely share a launching system with SLCMs and other missile types, will complicate matters further. There may also be uncertainty in each state's estimates of how many ships the other is likely to deploy. To be sure, this uncertainty is limited by the difficulty of hiding shipbuilding activities and of changing construction plans. Even so, it could be significant, particularly four or five years into the future.

Of course, without access to both Russian and U.S. classified information, it is impossible to determine whether official deployment estimates are indeed prone to exaggeration. It is perhaps significant, however, that well-connected Russian experts have used estimates of the United States' future force of "strategic conventional warheads"—including sea-based systems—that turned out to be inflated.⁴³ If there is a similar bias in official Russian and U.S. estimates, then the resulting increase in danger is entirely unnecessary (unless it is the result of a deliberate policy of ambiguity in SLCM deployments, and there is no evidence that it is). Moscow and Washington, therefore, should have a shared interest in greater transparency.

Solution Concept

In theory, limiting SLCMs and SLBGMs in a follow-on to New START would be the optimal solution. However, the challenges to doing so would be insurmountable—with the sole exception of making nuclear-armed SLBGMs accountable.⁴⁴ Given the military importance of nonnuclear SLCMs, in particular, neither the United States nor Russia would likely accept limits. Moreover, there would be daunting practical challenges. Most SLCMs are deployed on attack submarines and surface ships, and nonnuclear SLBGMs will likely be too. Neither Russia nor the United States has any interest in opening these vessels up to inspection.⁴⁵

Ensuring transparency about current and planned future deployments of nuclear and non-nuclear SLCMs and nonnuclear SLBGMs is a more practical way forward.⁴⁶ The proposed transparency arrangement outlined below is an expanded version of a U.S.-Soviet SLCM data exchange, which was negotiated as a side agreement to the Strategic Arms Reduction Treaty I (START I) and expired with that treaty in 2009.⁴⁷

U.S.-RUSSIAN DATA EXCHANGE ON SEA-LAUNCHED CRUISE MISSILES AND NONNUCLEAR SEA-LAUNCHED BOOST-GLIDE MISSILES

On April 1 and October 1 of each year, Russia and the United States should exchange confidential declarations of the number of missiles in the following categories that each state deployed on, respectively, March 1 and September 1 of the same year:

- Long-range nuclear-armed SLCMs
- Long-range nonnuclear SLCMs
- Long-range nonnuclear SLBGMs
- Nuclear-armed SLCMs with ranges between 300 and 600 kilometers (between 190 and 370 miles)
- Nonnuclear SLCMs with ranges between 300 and 600 kilometers
- Nonnuclear SLBGMs with ranges between 300 and 600 kilometers

The declaration covering deployments for March 1 should also include the following:

- The maximum number of missiles, in each category, that are anticipated to be deployed as of March 1 each year for the following five years
- All types of currently deployed surface ships and submarines, any one of which has ever been equipped with at least one SLCM or SLBGM launcher

In implementing these provisions, the following definitions would apply:

- “Boost-glide missile” means a weapon-delivery vehicle that sustains unpowered flight through the use of aerodynamic lift over most of its flight path. A reaction control system designed to change a vehicle’s attitude is not considered capable of powering flight.
- “Cruise missile” means an unmanned, self-propelled weapon-delivery vehicle that sustains flight through the use of aerodynamic lift over most of its flight path.

- “Deployed SLCM (or SLBGM)” means a cruise missile (or boost-glide missile) that is contained in any surface ship or submarine that is equipped with at least one SLCM (or SLBGM) launcher.
- “Long-range SLCM (or SLBGM)” means a SLCM (or SLBGM) with a range in excess of 600 kilometers.
- “SLCM (or SLBGM) launcher” means a device intended or used to contain, prepare for launch, and launch a SLCM (or SLBGM).

Definitions of missile ranges are discussed in appendix A.

Verification

This proposed transparency arrangement, which would lack legally binding verification provisions, would probably not be as effective as a treaty in building confidence in the current and future size of SLCM and SLBGM forces. It would, however, represent a significant improvement over the status quo (no regulation at all).

Importantly, Russia and the United States would not need to take the exchanged information purely on the basis of trust. If intelligence information available to either participant confirmed at least some parts of the other’s declaration, without contradicting other parts, it would boost the credibility of the declaration as a whole. Discussions could help to address any concerns—though they would not be easy. If one participant had intelligence information suggesting the other’s declaration was incorrect, it might not be able to explain the basis for its concerns without compromising the sources and methods used to collect the intelligence. Nonetheless, a constructive dialogue might still be possible. For instance, a participant might be able to build confidence in the planned size of its future navy by providing unclassified information about shipbuilding plans and potentially even allowing occasional visits to shipbuilding facilities.

Assessment

Technical feasibility. From a technical perspective, the proposed transparency regime should be straightforward to negotiate and implement.

Political feasibility. Russia and the United States each have concerns about the other’s current and future forces of SLCMs and nonnuclear SLBGMs. They may each appreciate greater insight into the other’s force. Such transparency could also mitigate the risks that could be caused by potentially exaggerated deployment estimates. A secondary benefit

for Moscow would be the possibility of using U.S. data to better estimate the number of Standard Missile-3 (SM-3) missile defense interceptors deployed on U.S. ships (those interceptors share launchers with SLCMs), thus helping to address Russian concerns about those interceptors. Although Russia has traditionally been skeptical of politically binding confidence-building measures, its participation in an earlier SLCM transparency arrangement sets a helpful precedent.

The primary political challenge to implementing this proposal would probably be the concern that exchanging classified data would undermine national security. The security risks, however, should be minimal. This proposal is narrowly tailored to mitigate one particular risk. It would not reveal a capability that was previously unknown to the other state or the precise mix of deployed weapon types—let alone the armaments on any particular ship. Therefore, unless either state seeks to use uncertainty about the scale of SLCM or SLBGM deployments to enhance deterrence, this data exchange should enhance the security of both states.

FIRST STEPS ON A TOUGH PROBLEM: A U.S.-RUSSIAN TRANSPARENCY REGIME FOR EMPTY WARHEAD STORAGE FACILITIES

THE UNITED STATES AND NATO have various concerns about Russia's large force of NSNWs, including the opacity surrounding those weapons' locations. Consistent with Russian commitments under the 1991–1992 Presidential Nuclear Initiatives, Moscow has stated that the warheads for its NSNWs are “stored in centralized storage facilities,” which means that they are consolidated away from delivery systems (not that storage facilities are centrally located within Russia).⁴⁸ While the United States has not publicly disputed this claim, the exact locations of Russia's nonstrategic nuclear warheads remain unverified.⁴⁹

The United States' only NSNWs are gravity bombs, which are reportedly held at six air bases in Europe and various additional locations in the United States.⁵⁰ The U.S. government has never confirmed these locations—not least to avoid drawing public attention to weapons whose presence their host states' populations generally oppose—and influential Russian analysts have sometimes expressed concern that U.S. nuclear gravity bombs may be stored at other European locations.

Russia may believe that ambiguity surrounding the locations of its NSNWs enhances its ability to deter NATO. Ambiguity, however, also creates real risks. NATO states, for example, have long been concerned about the possible presence of nonstrategic nuclear warheads in the Russian enclave of Kaliningrad.⁵¹ It remains unclear, however, whether the recently renovated storage facilities there currently house such warheads or whether Russia wants the option to introduce them at short notice.⁵² When coupled with associated concerns that Russia might use NSNWs early in a conflict, the possible presence of nuclear warheads in

the enclave is threatening and exacerbates tensions—potentially unnecessarily if, in fact, no warheads are present.

Moreover, in a conventional conflict, ambiguity could prove escalatory. If NATO wrongly believed that nuclear warheads were present in Kaliningrad, it might attack warhead storage facilities and potential dual-use delivery systems to forestall Russian nuclear use. Moscow might then conclude that such attacks represented the start of a broader conventional campaign against Kaliningrad, which is surrounded by NATO states and could be difficult to defend with exclusively nonnuclear means. As a result, Moscow might resort to the very nuclear use that NATO had sought to forestall.

These risks underscore the value of a cooperative effort to reduce uncertainty and potential misperceptions about the locations of nonstrategic nuclear warheads. Specifically, the absence of warheads at empty actual or suspected storage facilities could be verified through inspections. In this context, “empty” connotes the absence of all nuclear warheads, regardless of type. (Because of the difficulty of distinguishing strategic from nonstrategic warheads, it would be infeasible to inspect facilities at which strategic warheads were present but nonstrategic ones were not.) The goal here would be to enhance transparency around a limited number of pairs of facilities—say, two to five—of particular concern to NATO or Russia, *not* to create a comprehensive verification regime intended to cover every facility that has stored warheads or could do so.

Inspections of empty storage facilities would also facilitate progress toward the long-term goal of a more comprehensive management regime for NSNWs—an idea long supported by Washington in one form or another.⁵³ Such a regime, however, would face various practical difficulties, as U.S. officials have acknowledged in calling for Russia and the United States to undertake joint experiments to overcome verification obstacles.⁵⁴ The inspections proposed here would contribute to the development of a verification regime for a treaty, say, that prohibited NSNWs from being located anywhere except declared facilities, or more ambitiously, one that imposed a single limit on all warheads—strategic and nonstrategic, regardless of their deployment status (see chapter 9). This latter concept would require counting nondeployed warheads inside storage facilities. Inspections of empty facilities would advance this goal by creating joint understandings about, for example, how to prevent inspectors from learning classified information about storage facilities (such as their security features) and how to reach agreement on which areas of military bases should be open for inspections.

Solution Concept

Inspections of actual or suspected warhead storage facilities—even empty ones—would represent a new frontier for arms control but would build on experience from previous agreements. Russia and the United States would first need to negotiate a generic verification

protocol. Then to implement the protocol, NATO and Russia would have to negotiate and select pairs of sites—each pair containing one facility on NATO territory (including the United States) and one on Russian territory. Sites would be selected on the basis of mutual consent from Russia, the United States, and, in the case of a NATO facility located outside of the United States, the host state. Establishing an iterative process, in which lessons from each round of inspections were used to improve the generic verification protocol, would be particularly useful.

NATO has previously considered a similar concept and, as a first step, attempted to draw up a list of former warhead storage facilities that Russia could inspect (presumably on the basis of reciprocity). However, this process stalled amid bureaucratic and legal difficulties, including those created by many such facilities now being privately owned. The process proposed here would be simpler. NATO would not have to determine a comprehensive list of sites for inspection. Instead, it would have to assess the feasibility of inspections only at those sites of interest to Russia.

OVERVIEW OF AN INSPECTION REGIME TO VERIFY THE ABSENCE OF NUCLEAR WARHEADS AT SELECTED EMPTY ACTUAL OR SUSPECTED WARHEAD STORAGE FACILITIES

Russia and the United States should agree, on a politically binding basis, to reciprocal inspections of between two and five pairs of empty actual or suspected warhead storage facilities to demonstrate that they do not contain nuclear warheads.

They should then negotiate a generic verification protocol to verify the absence of nuclear warheads at an empty storage facility.

Russia and NATO should each propose, on the basis of its own intelligence information, candidate facilities that it wishes to inspect. From these lists, Russia and NATO should then jointly select one pair of facilities—one on NATO territory (including the United States) and one on Russian territory—for inspection. Facilities must be selected on the basis of mutual consent by Russia, the United States, and, for a facility located in a NATO state other than the United States, the host government.

In permitting a facility to be inspected, the host government would formally notify the inspecting state of the absence of nuclear warheads at the facility.

The United States and the host government would jointly facilitate all implementation activities for an inspection of a facility on NATO territory outside the United States.

Inspections to verify the absence of nuclear warheads should take place within sixty days of facility selection, following the exchange of baseline information and the negotiations over site-specific implementation arrangements.

After the first round of inspections, Russia and the United States should consult to discuss any problems that arose and refine the generic verification protocol accordingly. They should then repeat this process at one or more additional pairs of facilities.

There would be some risk of nuclear warheads' being removed from a facility in the time between facility selection and inspection—though the inspecting state would certainly monitor the facility closely with national technical means (NTM). While this risk would not be acceptable in a more comprehensive treaty, it should be tolerable in a politically binding confidence-building measure. In fact, this problem could be solved in a treaty with a provision that permitted inspectors to notify the host state of the inspection site only after their arrival in country, as is standard practice.

Verification

Baseline information exchange. A prerequisite to on-site inspections would be the exchange of baseline information about the selected facilities and the negotiation of site-specific implementation details. A key challenge here would be reaching agreement on the boundaries for inspection activities. Inspections would be feasible only if Russia and the United States could agree where nuclear warheads might conceivably be stored in a facility—thus precluding the need to inspect highly sensitive areas, such as communication centers, and avoiding very disruptive inspections of, for example, barracks or offices.

VERIFICATION: BASELINE INFORMATION EXCHANGE

Within ten days of facility selection, Russia and the United States, which should act jointly with the host state in the event of an inspection on the territory of another NATO member, should provide the other with simplified site diagrams that show the boundaries of the military base or other site on which the selected facility is located, all fixed structures within that boundary, and the prospective boundaries for inspection activities. The states should then negotiate, and mutually consent to, any changes to the prospective inspection boundaries.

Within twenty-five days of facility selection, Russia and the United States should exchange the following detailed baseline information about the selected facilities:

- A detailed inspection site diagram that conveys the agreed-upon inspection boundaries and the locations of any fixed structures within the inspection boundaries
- Diagrams of each fixed structure's interior, denoting all rooms (above- and below-grade) and interior and exterior access points

- A list of each warhead storage container and each storage container for nonnuclear munitions located within the inspection boundaries, denoting the container type and location
- The physical dimensions and a photograph of each type of warhead storage container located within the inspection boundaries
- The physical dimensions and a photograph of each type of storage container for nonnuclear munitions located within the inspection boundaries

After the exchange of information, Russia and the United States should address any questions regarding the selected facilities and inspection procedures.

In implementing these provisions, the following definitions would apply:

- “Fixed structure” means a unique structure that was previously used to store nuclear warheads, is designed to store nuclear warheads, or has an access point that is large enough for a warhead storage container to pass through.
- “Room” means an interior subdivision within or underneath a fixed structure with an interior that has an access point that is large enough for a warhead storage container to pass through.⁵⁵
- “Storage container for nonnuclear munitions” means any weapon container, other than a warhead storage container, whose linear dimensions when measured at their widest points are equal to or exceed the dimensions of the test object.

On-site inspections. The data exchange would enable each state to plan and conduct its inspection. One complication is the potential presence of weapon storage containers—whether empty storage containers for nuclear warheads or containers used to store nonnuclear munitions. Additionally, nonnuclear munitions outside of containers and other sensitive equipment, such as components for security systems, may also be present. The inspection protocol seeks to balance the intrusive access needed for credible verification with the protection of classified information that is not germane to the task of verifying the absence of nuclear warheads.

The protocol gives the host state the right to shroud any objects it deems to be sensitive. Meanwhile, it gives inspectors access rights to any location where a warhead could be hidden—as determined by the use of a cylindrical test object, representing the smallest plausible warhead storage container. If any warhead storage containers are present, inspectors may look inside to verify the absence of warheads (doing so should not reveal classified information unless a warhead is actually present in contravention of the state’s declaration). Inspectors can also use radiation detection equipment to verify that shrouded objects and storage containers for nonnuclear weapons do not contain nuclear material. Such technology has been used successfully pursuant to various previous U.S.-Russian arms control

agreements. Its application here could be somewhat more challenging because undeclared nuclear warheads could be more heavily shielded in storage than when deployed on delivery systems. On paper, this problem could be addressed by increasing the detection time—an issue that Russia and the United States could jointly consider while negotiating the generic verification protocol.

VERIFICATION: ON-SITE INSPECTIONS

Inspections should occur within sixty days of site selection. The inspecting state should inform the host state of the inspection date at least forty-eight hours in advance of the inspection team's arrival in country. All movement of vehicles and objects into or out of the inspection boundaries must cease twenty-four hours in advance of the inspection team's arrival in country.

Preliminary Inspection Procedures

After the inspection team's arrival at the facility, all vehicle traffic within the inspection boundaries must cease.

The host state's escort team should notify the inspection team of any changes in the previously supplied facility information and provide updated inspection site diagrams (though the inspection boundaries must not be altered). The escort team should also note the locations of any inspectable vehicles situated within the boundaries. The inspection team should be permitted to designate up to two such vehicles for inspection.

The escort team should present the cylindrical test object to the inspection team. The inspection team should have the right to measure the object to ensure that it conforms to the agreed length and diameter dimensions.

If there are any warhead storage containers or storage containers for nonnuclear munitions at the facility, the inspection team should be permitted to view one of each type to verify their dimensions and to compare them to the photographs provided as part of the baseline information exchange.

Once preliminary inspection procedures are complete, any vehicles located within the inspection boundaries, other than those that have been designated for inspection, may resume movement.

Facility and Designated Vehicle Inspections

The duration of the facility inspection should be limited to twelve hours. During that period, for the sole purpose of verifying the absence of nuclear warheads, the inspection team should be given access first to any inspectable vehicles designed for inspection and then, in whatever order the team chooses, to any warhead storage containers, storage containers for nonnuclear munitions, and rooms that it selects. After each designated

inspectable vehicle (if any) has been inspected, the host state may move it. The escort team should be permitted to accompany the inspection team at all times.

The host state should have the right to shroud, in advance of the inspection, any items other than warhead storage containers that it deems sensitive. The inspection team should have the right to request that the escort team open any warhead storage container to verify that it does not contain a nuclear warhead. The inspection team should also have the right to employ radiation detection equipment to confirm that any shrouded objects, storage containers for nonnuclear munitions, or other objects (other than warhead storage containers) do not contain nuclear material.

Undeclared Structures, Objects, and Vehicles

Should the inspection team observe, within the inspection boundaries, an undeclared fixed structure, warhead storage container, storage container for nonnuclear munitions, room, or inspectable vehicle, the escort team should be required to perform measurements to verify whether it is large enough to contain a nuclear warhead. If it is, inspectors must be provided with access. The duration of such access should not count toward the twelve-hour time limit for the inspection.

Access Point Characterization

An access point should be deemed large enough for a warhead storage container to pass through if the test object, in any orientation, can pass through it. The test object should be a cylinder with a length of 1 meter (3.3 feet) and a diameter of 0.5 meters (1.6 feet) and be constructed of lightweight materials.⁵⁶

In implementing these provisions, the following definition would apply:

- “Inspectable vehicle” means a vehicle that has an access point large enough for a warhead storage container to pass through.

Assessment

Technical feasibility. In crafting a verification protocol, Russia and the United States could draw upon their considerable experience of conducting inspections at sensitive facilities and using radiation detection equipment for verification purposes. Moreover, they would not have to address the various complications associated with inspecting facilities at which nuclear warheads are present. Yet significant challenges—such as the need to agree on inspection boundaries—would remain. These challenges appear manageable, but the only way to know for sure would be for Russia and the United States to try to negotiate and implement the proposed agreement.

Political feasibility. The United States and its NATO allies have clear concerns about the locations of Russia's nonstrategic nuclear warheads. And there is some evidence that these concerns are reciprocal.⁵⁷ But even if Moscow does not currently have concerns about the locations of U.S. NSNWs in Europe, it could easily become concerned in the context of a reinvigorated arms race. Therefore, all states would benefit directly from enhanced transparency. This proposal would benefit the United States and NATO more than Russia, however, and so it would likely need to be paired with a measure of more interest to Russia—perhaps the confidence-building regime for Aegis Ashore launchers in Europe (see chapter 3).

At least three other political challenges could also arise. First, the proposed agreement may go too far for Russia and not far enough for the United States. The United States seeks a comprehensive regime for managing NSNWs. However, Moscow has repeatedly rejected this concept; indeed, it appears to be sticking to its long-standing position that U.S. nuclear weapons based in Europe must be returned to the United States and their storage infrastructure permanently dismantled before negotiations on limiting NSNWs can begin.⁵⁸ This proposal could help to break the logjam. It would not require negotiations over limits on NSNWs but would build experience and confidence in inspecting warhead storage facilities, thus making progress toward the goal of a more comprehensive treaty.

Second, it could be challenging for Russia and the United States to select facilities for inspection. There would presumably be some empty actual or suspected warhead storage facilities at which an inspection request could not be accommodated; some are likely too sensitive, and others, such as former warhead storage facilities now in private hands, may present insurmountable bureaucratic and legal difficulties. Because facilities must be selected by mutual consent, the host state could always veto an inspection request. This veto power represents an important safeguard—though if it were used too often, the proposed agreement would likely fall apart amid reciprocal accusations of bad faith.

Finally, inspections in Europe could create particular legal, diplomatic, and political complications. While navigating these difficulties would not be entirely straightforward, they were successfully tackled in implementing the INF Treaty, which suggests that they should not be insurmountable.

CHAPTER 3

BREAKING THE LOGJAM: A U.S.-RUSSIAN CONFIDENCE- BUILDING REGIME FOR EUROPEAN MISSILE DEFENSES

WITHIN THE BROADER U.S.-Russian dispute over missile defense, a particular point of contention is the United States' European Phased Adaptive Approach (EPAA). This initiative seeks to defend NATO against Iran.⁵⁹ To this end, the United States has deployed SM-3 Block IB interceptors in Romania. It now plans to deploy more capable SM-3 Block IIA interceptors at the same site and at a second site in Poland. The launchers at each of these Aegis Ashore installations are adapted from the U.S. Navy's MK-41 Vertical Launching System, which is used on ships equipped with the Aegis air and missile defense system to launch SLCMs and other missiles as well as SM-3 interceptors.

Russia believes that the EPAA may threaten its ability to target the United States with ICBMs. The United States' November 2020 test of an SM-3 Block IIA interceptor against an ICBM-class target has added to Moscow's unease.⁶⁰ The U.S. Department of Defense contends that this interceptor "has the potential" to contribute to the defense of the homeland against "rogue states" ICBMs, which have less capability to penetrate defenses than Russian ICBMs.⁶¹ Moreover, to be useful for homeland defense, SM-3 Block IIA interceptors would need to be deployed near the United States; systems located in Europe would be unable to catch a Russian ICBM. These considerations do not seem to have assured Moscow, however, which may have overestimated the capabilities of the SM-3 interceptor—in particular, its burnout speed (that is, its maximum speed, which is reached immediately after its motors have ceased firing).

Russia's concerns about the EPAA extend beyond the interception of its ICBMs to the possibility that the launchers could be used to fire offensive missiles, particularly cruise missiles. In

response, the U.S. Department of State has indicated that the “Aegis Ashore Missile Defense System” (a term that appears to include more than just the launchers themselves) “lacks the software, fire control hardware, support equipment, and other infrastructure” required for launching offensive missiles.⁶² It has also stated that “the defensive nature of the Aegis Ashore sites is documented in U.S. basing agreements” with Poland and Romania.⁶³ Russia has made clear that it places little value on these assurances, noting, for example, that the United States has conducted a test launch of a cruise missile from a land-based MK-41 test launcher.⁶⁴

The United States and its NATO allies have compelling reasons to try to address Russia’s concerns. Most importantly, such concerns could spark inadvertent escalation. Moscow has threatened to attack Aegis Ashore installations preemptively in a crisis or conflict—presumably both to ensure the effectiveness of its nuclear deterrent and to prevent cruise missile attacks that could undermine its ability to wage a conventional war.⁶⁵ Meanwhile, in peacetime, Russian concerns complicate the development of arms control agreements, including measures to manage the Poseidon torpedo and Burevestnik cruise missile, which Russia is developing to penetrate U.S. missile defenses. Indeed, if Russian concerns about missile defense are not successfully managed, Moscow may take further countermeasures—such as the expansion of its strategic nuclear forces or the development of additional kinds of exotic strategic delivery systems—adding yet more fuel to the incipient arms race.

Solution Concept

Efforts to manage the dispute over Aegis Ashore should focus on the development of a transparency regime to demonstrate that (1) SM-3 interceptors located in Europe cannot threaten Russian ICBMs because they have insufficient burnout speed and (2) European Aegis Ashore installations cannot launch offensive missiles or do not contain missiles other than SM-3 interceptors. Successfully implementing this regime would not resolve the entire missile defense dispute or even address all of Russia’s concerns about the EPAA.⁶⁶ However, it would ameliorate an acute part of the problem and could also catalyze a process for managing other Russian and U.S. concerns. Washington could indicate that if the transparency regime for Aegis Ashore installations is implemented successfully and if Russia starts to address U.S. concerns on NSNWs—by, for example, agreeing to inspections of empty warhead storage facilities (see chapter 2)—then the United States will be willing to negotiate additional steps to manage the missile defense dispute.

A TRANSPARENCY REGIME FOR EUROPEAN AEGIS ASHORE INSTALLATIONS

At the invitation of the United States, Russia should observe one flight test of an SM-3 Block IB interceptor and one of an SM-3 Block IIA interceptor to measure, with Russian equipment, the interceptors’ burnout speeds.

The United States should commit to (1) notifying Russia in advance of the first European deployment of any type of missile defense interceptor with a burnout speed greater than 3 kilometers per second (1.9 miles per second) and (2) inviting Russia to observe, at least sixty days prior to the interceptor's first deployment in Europe, a flight test to measure, with Russian equipment, the interceptor's burnout speed.

The United States should commit to refrain from using any denial and deception practices that would interfere with Russian measurements of the interceptor's speed during any test observed by Russia pursuant to this agreement.

The United States should reaffirm to Russia the exclusively defensive purpose of European Aegis Ashore installations and commit to refrain from (1) loading offensive missiles into European Aegis Ashore launchers and (2) modifying such launchers so they become capable of launching offensive missiles. The United States should further commit to engage in good-faith negotiations with Russia over practical transparency measures, including inspections and/or the use of remote monitoring equipment.

Russia should agree to take equivalent steps if it deploys in Europe any missile defense interceptors with burnout speeds greater than 3 kilometers per second on ground-based launchers derived from naval vertical launching systems.

In 2011, the administration of then U.S. president Barack Obama invited Russia to measure an SM-3 interceptor's burnout speed—though the proposal appeared to apply to just one flight test.⁶⁷ Moscow rejected that overture as “propagandistic.”⁶⁸ The current proposal will hopefully be more attractive because it is more comprehensive. It would apply to each interceptor type that has been or will be deployed in Europe unless its burnout speed is lower than 3 kilometers per second, in which case it could not meaningfully contribute to strategic missile defense operations—as Russia and the United States previously agreed.⁶⁹ Meanwhile, the confidence-building measures relating to offensive missiles aim to operationalize U.S. commitments already made to Poland and Romania about the exclusively defensive purpose of Aegis Ashore installations.

Verification

Interceptor burnout speed. The United States generally conducts interceptor flight tests from the Pacific Missile Range Facility in Hawaii. Russia could use its missile range instrumentation ship, the *Marshal Krylov*, to measure the interceptor's burnout speed.⁷⁰ Given that this ship's radar likely has a range in excess of 600 kilometers, the vessel could be positioned on the high seas (that is, in international waters) at a site of Russia's choosing. As such, Russia does not actually need an invitation to monitor U.S. interceptor flight tests—though cooperation would have two advantages. First, the United States would inform Russia of the test in advance, giving it time to position the ship. Second, the United States would commit not to interfere with Russian measurements of the interceptor's speed.

Exclusively defensive purpose of European Aegis Ashore installations. The first step in developing any verification approach would be meetings between U.S. and Russian officials, including technical experts, so that the United States could identify some or all of the “fire control hardware, support equipment, and other infrastructure” that is missing from European Aegis Ashore installations and thus renders them incapable of launching cruise missiles.⁷¹ As part of this process, the United States should provide Russia with commercial

The confidence-building measures relating to offensive missiles aim to operationalize U.S. commitments already made to Poland and Romania about the exclusively defensive purpose of Aegis Ashore installations.

satellite imagery and internal and external photographs that highlight differences between Aegis Ashore installations and their sea-based equivalents. The United States could also consider offering Russia a one-off exhibition of the land-based MK-41 test launcher in California—which has been used to launch a cruise missile—and, with the host state’s permission, an Aegis Ashore installation in Europe.

Based on this information, the two sides should then attempt to jointly identify externally observable distinguishing features (EODFs) between the land- and sea-based launchers. The outcome of this exercise would determine the optimal verification approach.

The most straightforward case would arise if the two sides jointly identified EODFs that could be detected with satellite imagery. Verification could then be facilitated by a U.S. commitment not to interfere with Russian NTM—a common feature of many arms control agreements that might be generally helpful in addressing Russian concerns about the EPAA.

A second possibility is that EODFs are identified but are visible only from the ground. In this scenario, periodic on-site inspections, with the host nation’s consent, would be needed so Russian inspectors could verify the absence of one or more components needed to launch cruise missiles.

The third and most challenging case would arise if the United States and Russia were unable to jointly identify any EODFs. The most direct approach to verification would then be for the United States to permit Russian inspectors to periodically select and view the inside of an agreed number of Aegis Ashore launchers to check that they are loaded with missile defense interceptors and not cruise missiles (similar to inspections of the missiles inside ICBM silos or SSBN launch tubes pursuant to New START). To facilitate such inspections, which would again require the host government’s consent, the United States should provide Russia with identifying characteristics for each type of missile defense interceptor deployed in European Aegis Ashore launchers (fortunately, SM-3 interceptors look very different from Tomahawk cruise missiles).

Under any scenario, Russia could use NTM to try to detect the loading of offensive missiles into launchers. It therefore could be helpful for U.S. technical experts to explain to their Russian counterparts how the loading of interceptors and offensive missiles can be distinguished—if indeed they can. Such cooperation would be particularly important if Russia and the United States failed to identify any EODFs and if the United States was unwilling to allow Russian inspectors to view the interceptors inside launchers. In this case, to enhance Russia’s ability to detect any loading of offensive missiles, the United States could (1) permit Russian inspectors to install and use remote monitoring video equipment so Russia could continuously observe specified areas of European Aegis Ashore installations and (2) commit to notifying Russia at least twenty-four hours in advance of the loading or unloading of European Aegis Ashore launchers so it has time to make any necessary preparations for observing the process with NTM.

On-site access of any kind would require Russia and the United States to negotiate a politically binding verification protocol. From a U.S. perspective, a key consideration would be ensuring that Russian inspectors could not learn classified information other than that officially disclosed pursuant to the inspection agreement. To this end, the shrouding of equipment not subject to inspection could be helpful. A separate agreement between the United States and each host nation would also be needed.

Assessment

Technical feasibility. Designing a regime to verify the exclusively defensive nature of Aegis Ashore installations could prove tricky. The primary challenge would probably be the joint identification of EODFs—an issue that Russia and the United States have frequently disagreed on in other contexts. If the two states failed to agree on EODFs, it might nonetheless be possible for Russia to ascertain that the launchers are configured for defensive purposes by verifying they are loaded with interceptors and not cruise missiles.

Measuring the burnout speed of an interceptor should be straightforward for Russia, which would rely on its own equipment. This speed is probably the single most important parameter for determining the extent of any threat posed by European Aegis Ashore installations to Russian ICBMs—but it is not the only one. As a result, Russia’s gaining confidence in this speed should reduce the scope for disagreement between Moscow and Washington but might not eliminate it entirely. Therefore, this proposal would be best implemented as part of a broader U.S.-Russian dialogue over missile defense, in which the two sides could discuss how to determine whether defenses threaten ICBMs.

Political feasibility. This proposed measure is intended to address Russian concerns and should be paired with one to address U.S. concerns, such as inspections of empty warhead storage facilities (see chapter 2). Even if it is, however, the proposal would stir up controversy within both the United States and NATO. Domestic critics would probably argue, as

they did in 2011, that permitting Russia to measure the burnout speed of a U.S. interceptor would disclose classified information that could compromise national security. Yet, as the Obama administration concluded back then, this information would not meaningfully help Russia (or any third party to which Russia disclosed this information) to defeat U.S. defenses. Critically, to protect against Russia's learning much more sensitive information (such as the performance of the interceptor's sensors), the United States could continue to use denial and deception techniques (such as the encryption of telemetry data) that did not interfere with Russian speed measurements. Meanwhile, orchestrating Russian inspections on the territory of a U.S. ally would be politically sensitive, but, as history demonstrates, hardly infeasible.

All these difficulties, however, pale compared to the long-standing acrimony between Russia and the United States on missile defense. The two states have long approached this issue with seemingly irreconcilable positions. Moscow has demanded legally binding guarantees without giving any indication that it is willing to offer the United States anything in return. Washington has insisted that it can offer nothing more than politically binding confidence-building measures—that is, when it is prepared to engage at all.

Today, however, there is an opening for progress, albeit a slight one. Russian officials have indicated a new willingness to consider politically binding confidence-building measures. The Biden administration, meanwhile, appears to be more willing than its predecessor to try to address Russian concerns. To improve the prospects for progress, Washington should frame this proposal as the first step in a long-term process to address a wider range of concerns that could potentially include the development of legally binding instruments. In this spirit, this proposal would not be a one-off exercise; it would permit Russia to measure the burnout speed of each interceptor type deployed in Europe and would provide Russia with an ongoing and verified commitment about the exclusively defensive purpose of European Aegis Ashore installations.

CHAPTER 4

BEYOND (TRADITIONAL) BILATERALISM: A U.S.-CHINESE FISSILE MATERIAL MANAGEMENT REGIME

AS CHINA EXPANDS ITS nuclear forces—a process that the U.S. government expects to continue—a broad consensus within the U.S. national security community about the importance of engaging China in arms control has emerged. The administration of U.S. president Donald Trump unsuccessfully sought to engage China and Russia in negotiations toward a trilateral treaty.⁷² The Biden administration has indicated it will seek to engage China and Russia separately. However, in public at least, it has not yet made any specific proposals for bilateral U.S.-Chinese arms control measures but instead has called generally for the two states to pursue “practical measures to reduce the risks of destabilizing arms races.”⁷³

Beijing, meanwhile, has consistently rebuffed the United States’ entreaties, suggesting—without committing—that it will join multilateral disarmament negotiations only after the United States has reduced its nuclear arsenal to close the “huge gap” with China.⁷⁴ Beijing has various concerns about engaging in arms control, but an important one is likely that verification might undermine the survivability of China’s nuclear forces by revealing sensitive information about them—the location of individual weapons, in particular.⁷⁵

The United States cannot force China to negotiate. The Trump administration succeeded in demonstrating this lack of leverage through its fruitless call for Moscow to “bring China to the negotiating table,” and its discussion of conducting a nuclear test to pressure Beijing (a step that would likely have ended up fueling arms racing).⁷⁶ Instead, if Washington is to have any chance of engaging China in arms control, it will have to craft proposals

that mitigate Chinese concerns about transparency, while also identifying suitably valuable American concessions that could form part of a mutually beneficial quid pro quo. (China should undertake such thinking too as a good-faith effort to comply with Article VI of the Nuclear Non-Proliferation Treaty; as a practical matter, however, since it is the United States that wants to engage China, it is going to be up to Washington to work out how to entice Beijing to the negotiating table.)

Against this background, limits on warheads or even missiles would be a nonstarter. The limiting of launchers and bombers (see chapter 8) would be more viable, though is still an ambitious, long-term goal. For the time being, the most promising, albeit still challenging, approach is to focus on fissile material—the separated plutonium and highly enriched uranium (HEU) needed to produce nuclear warheads.

If China seeks to build up its nuclear forces to the point where they rival the United States' arsenal in size, it will have to manufacture more than 3,000 additional nuclear warheads. According to the U.S. Defense Intelligence Agency, however, even if China converted all its available fissile material into nuclear weapons, its arsenal would still comprise only several hundred warheads (perhaps double its current stockpile).⁷⁷ As a result, U.S. concerns about a Chinese nuclear buildup could be addressed by seeking to prevent any new production of fissile material.

Solution Concept

China and the United States should jointly declare a cutoff in fissile material production and adopt transparency measures to enhance this cutoff's credibility. Ideally, the cutoff would extend to all fissile material production. In the real world, a more plausible approach would be for China and the United States to agree not to produce any more fissile material for military purposes and to place all newly produced civil material under International Atomic Energy Agency (IAEA) safeguards.

The United States unilaterally ceased the production of fissile material for any purpose, civil or military, almost thirty years ago and has no plans to restart it (indeed, it could expand its arsenal dramatically without doing so). It also published comprehensive declarations of its plutonium and HEU stockpiles in the mid-1990s—though has provided only one update (to the HEU declaration) since.⁷⁸

There are widespread reports that China has ceased the production of weapon-usable fissile material for military purposes.⁷⁹ However, Beijing has never officially confirmed them—possibly because it wants to retain the option of producing more such material.

China has ambitious plans to develop a civil reprocessing program.⁸⁰ Its only existing civil reprocessing facility, a pilot plant with a small throughput, is probably no longer operational—though there is uncertainty here because, starting in 2018, China ceased to submit

updates on its civil plutonium stockpile to a voluntary IAEA transparency initiative known as INFCIRC/549 (the United States remains an active participant).⁸¹ China is currently constructing one “demonstration” reprocessing plant and appears to be starting work on a second.⁸² Over the longer term, it aims to develop one or more industrial-scale facilities.

There is now growing concern within the United States that plutonium separated in these plants may be diverted for use in China’s nuclear weapons program. This concern has been fueled by China’s ambitious nuclear modernization efforts and by its plans to develop so-called fast reactors that will (if they can be made to work) produce plutonium particularly suitable for use in nuclear warheads. Given China is unlikely to relinquish its reprocessing program, a commitment to allow the IAEA to safeguard all newly produced civil fissile material could be the basis for a compromise.

A JOINT U.S.-CHINESE FISSILE MATERIAL CUTOFF AND ASSOCIATED TRANSPARENCY ARRANGEMENTS

China and the United States should declare a joint politically binding cutoff in the production of weapon-usable fissile material for any purpose and commit to talks about mutual confidence building.

If China is unwilling to agree to a complete cutoff because it is still producing, or plans to produce, fissile material for civil purposes, it should agree to a cutoff in production for military purposes and to place all newly produced HEU and separated plutonium under IAEA safeguards.

After agreeing to a cutoff, China and the United States should exchange confidential declarations about their stockpiles of weapon-usable fissile material. Specifically, for each of the following categories, each state should make annual declarations of its total holdings of (1) separated plutonium (unless it contains more than 80 percent plutonium-238) and (2) uranium-235 contained in uranium enriched to more than 20 percent:

- **Military material**—material (other than excess military material) that has been fabricated, or is reserved for potential future fabrication, into nuclear weapon components
- **Excess military material**—former military material that a state has committed not to use for military purposes
- **Naval fuel**—irradiated or unirradiated fuel for military naval reactors
- **Other military material**—material used for other military purposes (such as fresh or irradiated fuel for military research reactors)
- **Civil material**—material involved exclusively in civil nuclear activities

The fissile material declarations are a confidence-building measure intended to complement the cutoff by providing comprehensive and regularly updated information about each state's fissile material stockpiles. They would build on the United States' previous voluntary declarations and on the information about civil fissile material that the United States makes available through INFCIRC/549 and that China used to make available through that same mechanism.

Verification

After committing to a bilateral cutoff in the production of weapon-usable fissile material, China and the United States should discuss any compliance concerns, with the aim of developing ad hoc verification measures to alleviate those specific concerns.

Verifying a cutoff in plutonium production should be unproblematic. The United States surely already uses NTM to monitor the nonoperational status of China's military plutonium-production program. Similarly, China must use NTM to verify that U.S. military plutonium-production reactors and reprocessing plants are being decommissioned.⁸³

Verifying a cutoff in HEU production could be slightly more challenging. China and the United States operate civil enrichment facilities to produce low enriched uranium, primarily for nuclear power reactors.⁸⁴ However, all these facilities are technically capable of producing HEU, and China's Heping facility—in which HEU for nuclear weapons was produced—may currently produce HEU for research reactors.⁸⁵ If so, under a cutoff, such production would have to cease or be placed under IAEA safeguards.

Confirming the nonproduction of HEU at enrichment facilities would require physical access, which, to be politically palatable, would have to be reciprocal. While inspections conducted by either the IAEA or national inspectors would be intrusive, there would be few technical difficulties.

To verify that HEU is not being produced in an operational enrichment plant that has never produced such material, swipe samples could be taken and analyzed to confirm the absence of HEU particles. If such a plant has produced HEU, it might be possible to check that production has ceased by determining the minimum age of HEU particles.⁸⁶ Failing that, the enrichment level of product streams could be measured through online enrichment monitors or periodic sampling. Finally, if either state were concerned that the other had built a secret enrichment plant to produce HEU for military purposes, swipe samples could again be used to confirm the absence of HEU particles at the suspect facility (if needed, the host state could use extensive shrouding to protect unrelated classified information).

In contrast to verifying a cutoff, the comprehensive verification of stockpile declarations would be functionally impossible. One reason is that classification rules around weapon components would prevent inspectors from measuring their fissile material content. That

said, each state could compare the other's declarations to its own intelligence estimates and commit to discussing inconsistencies. In particular, the past production of fissile material would be a less sensitive subject than its subsequent use or current disposition. It might therefore be possible to address discrepancies over production by being transparent about the operational histories of relevant facilities and by potentially using nuclear archeology (which involves analyzing components in facilities and waste streams to estimate past production).

Assessment

Technical feasibility. Verifying a cutoff should be relatively straightforward, even if potentially intrusive. By contrast, verifying stockpile declarations, at least in any comprehensive way, would be impossible. Ultimately, China and the United States would have to decide whether or not they were better off receiving additional information, even if they could not verify it.

Political feasibility. This proposal would benefit the United States more than China—at least if implemented by itself. The United States has far more fissile material for nuclear weapons than it has use for, even though production ceased almost three decades ago. China, by contrast, has a much smaller stockpile, and while Beijing may not be producing more fissile material for nuclear weapons right now, it probably wants to maintain the option to do so. Indeed, China is probably quite pleased that Pakistan has blocked negotiations over a multilateral fissile material cutoff treaty, even if Beijing pays lip service to the goal of concluding such an agreement.⁸⁷

In some ways, a bilateral agreement with the United States may be more problematic for Beijing than a multilateral treaty because it would not cover all the other countries that affect China's fissile material requirements (namely, India, Russia, and perhaps even Japan). Nonetheless, Beijing has three potential motivations to explore this proposal.

Beijing may be reluctant to abandon the option of producing more fissile material because it is concerned about the survivability of its nuclear forces and believes it may need to manufacture more nuclear warheads in the future.

First, in practice, the proposed measure would not be implemented by itself. Inevitably, it would have to be adopted as part of a mutually beneficial package that required the United States to make significant concessions. To facilitate negotiations over such a package, Beijing should start considering what it would ask of Washington. Meanwhile, U.S. and Chinese experts could explore the trade space informally.

Beijing may be reluctant to abandon the option of producing more fissile material because it is concerned about the survivability of its nuclear forces and believes it may need to

manufacture more nuclear warheads in the future. Chinese concerns on this score are driven, in no small part, by U.S. ballistic missile defense programs. At least in theory, space-based missile defenses would provide the most plausible means for the United States to undermine China's nuclear deterrent and are a source of acute concern for Chinese experts.⁸⁸ So, at the same time that China and the United States agreed to a politically binding cutoff in fissile material production, they could also agree, on a politically binding basis again, not to test or deploy space-based missile defenses. Such an agreement would be a step toward a legally binding trilateral prohibition (see chapter 7).

Second, in private, some Chinese officials and experts question the accuracy of the United States' fissile material declarations. This proposal would help China gain deeper insight into the U.S. stockpile.

Third, while fissile material is unquestionably a sensitive issue for Beijing, this proposal would presumably be more acceptable to China than many, if not all, of the alternatives—binding limits on nuclear forces, in particular. Such limits would reveal the exact size of China's nuclear arsenal and the locations of its weapons, exacerbating Beijing's concerns about their vulnerability. By contrast, stockpile declarations would reveal only an approximate maximum size of China's nuclear arsenal and nothing about weapon locations. To be sure, Beijing does not need to choose any of the alternatives; it could simply continue not to engage. Yet Chinese leaders should ponder the advice of the scholar Tong Zhao, who has argued that arms control could enhance China's interests by preventing dangerously destructive competition with the United States, by bolstering China's image as a responsible power, and by reducing defense spending.⁸⁹ If those leaders agree with this argument in principle, this proposal could be part of a practical way forward.

PREVENTING THE SPARK: A TRILATERAL LAUNCH NOTIFICATION AGREEMENT

IF MISTAKEN for an attack, a ballistic missile test, missile defense test, or space launch could spark escalation. This risk is not hypothetical. In January 1995, Russia mistook a sounding rocket launched off the Norwegian coast for a U.S. nuclear-armed ballistic missile. Because Moscow feared that the first wave of a U.S. campaign to destroy its nuclear forces might comprise a small number of ballistic missiles—perhaps just one—fired against key command-and-control nodes, the result was a cascade of warnings that reached Russian president Boris Yeltsin within four minutes.⁹⁰ Only after he activated his “nuclear briefcase” and ordered the Strategic Rocket Force to prepare to launch ICBMs did the Russian military determine that the launch was benign.

Twenty-five years later, notwithstanding subsequent improvements in Russia’s early-warning capabilities, there remains a real risk that escalation could result from either a mischaracterized launch or, relatedly, from preparations for a test launch being mistaken as preparations for an attack—a scenario that would invite a preemptive strike against the launch site. There are two reasons to take these dangers seriously.

First, while the risks of escalation may be low in peacetime, they could rise significantly at times of heightened tensions. During such periods, national and military leaders might be more inclined to interpret an ambiguous event in the worst possible light because they were expecting or, at least, were concerned about an attack.⁹¹ Moreover, a state that feared that an attack might be underway or imminent would be more likely to respond precipitously in

a crisis than in peacetime. Second, currently, the danger of inadvertent escalation resulting from a test or space launch (or its preparations) would be limited to a crisis involving Russia and the United States because they are the only two states with the capability to detect a ballistic missile attack and launch some of their own nuclear forces before the incoming weapons had detonated. China, however, is now acquiring a similar launch-under-attack capability, creating the possibility that these dangers could soon arise in a U.S.-Chinese crisis too.

Notifications before test or space launches can help reduce these risks. There are two operative notification agreements involving Russia and the United States: the 1988 U.S.-Soviet Ballistic Missile Launch Notification Agreement, which was made legally binding through its incorporation into New START, and the multilateral 2002 Hague Code of Conduct Against Ballistic Missile Proliferation, a politically binding document that calls for notifications of space launches (among many other provisions). Separately, in 2009, China and Russia concluded their own legally binding notification arrangement, the Agreement on Notifications of Launches of Ballistic Missiles and Space Launch Vehicles, which was extended in 2020 for ten years.⁹² (See table 1 for a comparison of the notification commitments.)

This patchwork of agreements has five particularly notable gaps, however. First, China and the United States have not agreed to exchange any launch notifications.⁹³ Second, as indicated in table 1, the range thresholds that trigger notification requirements are generally quite long. Yet tests of shorter-range missiles could also spark escalation if conducted from ships or aircraft close to an adversary's borders or from the territory of, or in the direction of, a U.S. ally. Third, no state has committed to providing notifications about tests of boost-glide missiles. Because boost-glide missiles are maneuverable, their tests are actually more likely to be misinterpreted as attacks than tests of ballistic missiles, which fly along predictable trajectories after burnout. Fourth, no state has agreed to notify others of missile defense tests, even though either the interceptor or the target missile, which could follow a ballistic or boost-glide trajectory, could be interpreted as a threatening offensive missile prior to interception (or self-destruction, should interception not occur). Fifth, there is currently no requirement on any state to provide notifications of any sub-orbital space launch—that is, a launch that places an object on a trajectory that returns to Earth, as opposed to a trajectory that takes it into Earth orbit or outer space. Yet such tests, which can be conducted for scientific research or for the development of direct-ascent anti-satellite weapons, can be misinterpreted as attacks—as the 1995 sounding rocket incident demonstrates.

Solution Concept

These deficiencies, paired with China's increasing capability to detect missile launches, suggest that China, Russia, and the United States should share an interest in developing a more comprehensive approach to launch notifications.⁹⁴ The proposal for a trilateral regime

TABLE 1
COMPARISON OF LAUNCH NOTIFICATION REGIMES

| Notification Requirement | China-Russia (2009 agreement) | Russia-United States (1988 agreement) | China- United States |
|---|--|--|------------------------------|
| Minimum range of ground-launched ballistic missile | 2,000 kilometers (1,200 miles) | 5,500 kilometers (3,400 miles) | No notifications required |
| Minimum range of submarine-launched ballistic missile | 2,000 kilometers | 600 kilometers (370 miles) | |
| Minimum range of air-launched ballistic missile | 2,000 kilometers | No notification required | |
| Boost-glide missile test | No | No | |
| Missile defense test | No | No | |
| Direction of test | Toward the other state ^a | Any | |
| Post-launch notification | Yes | No | |
| Space launch to Earth orbit or outer space | Yes | Yes ^b | |
| Sub-orbital space launch | No | No | |
| Exemption for special cases | Yes | No | |

^a China is required to notify Russia of launches to the west, northwest, north, and northeast. Russia is required to notify China of launches to the northeast, east, southeast, and south.

^b Pursuant to the Hague Code of Conduct.

described below includes elements from the 1988 U.S.-Soviet and 2009 Chinese-Russian agreements, as well as from a never-implemented 2000 memorandum of understanding between Russia and the United States to enhance their notification regime. Helpfully, all these agreements contain various identical or almost identical definitions and rules (such as the instructions for describing the planned impact area of a missile test).

The following proposal aims to address all five lacunae. Notifications would be required for launches that exceed a certain minimum threshold for planned distance, apex altitude, or speed, depending on the type of launch (the risks of escalation from tests that do not meet the threshold would be small). In the case of U.S. missile defense tests, these thresholds would require Washington to report on tests of SM-3 interceptors and Ground-Based Interceptors, but not on slower systems, such as Terminal High Altitude Area Defense interceptors (of course, the thresholds would apply to all participants of the agreement equally).

A TRILATERAL MISSILE LAUNCH NOTIFICATION REGIME

China, Russia, and the United States should agree to notify one another of the following:

- All space launches
- All test launches of ballistic or boost-glide missiles—whether conducted from air, land, or sea—that meet a specific condition:
 - **For tests of ballistic missiles:** The planned distance between the launch point and the impact point exceeds 500 kilometers (310 miles), or the planned apex altitude exceeds 500 kilometers.
 - **For tests of boost-glide missiles:** The planned distance between the launch point and impact point exceeds 500 kilometers or the planned maximum speed exceeds 2 kilometers per second (1.2 miles per second).
- All test launches of missile defense interceptors conducted from air, land, or sea, and all launches of target missiles used in such tests, if the planned trajectory for either the interceptor or the target missile meets a specific condition:
 - **For missile defense interceptors and target missiles intended to simulate the trajectory of ballistic missiles:** The planned distance between the launch point and extrapolated impact point exceeds 500 kilometers, or the planned extrapolated apex altitude exceeds 500 kilometers.
 - **For target missiles intended to simulate the trajectory of boost-glide missiles:** The planned distance between the launch point and extrapolated impact point exceeds 500 kilometers, or the planned maximum speed exceeds 2 kilometers per second.

Both pre-launch notifications and post-launch notifications (or, if a launch did not take place, a cancellation notification) should be provided.

Pre-launch notifications should be provided at least twenty-four hours before the start of the launch window and should include the following:

- The type of launch (space launch, ballistic missile test, boost-glide missile test, or missile defense test)
- The total number of launch systems to be launched
- The basing mode (ground-launched, sea-launched, or air-launched) of each launch system
- The launch area of each launch system (for ground-based or air-based launches, the site, facility, or range; for sea-based launches, the ocean quadrant or body of water, such as a sea or bay)

- The planned payload impact area of each launch system, if there is one; otherwise the launch azimuth (the size of the impact area may be determined by the notifying state at its discretion)
- The time and date for the start and end of the launch window (which may last no longer than seven days, unless extended through a notification)

A single pre-launch notification may be used for multiple launches only if the last launch in the sequence is planned to occur less than sixty minutes after the first launch and if all launches are of the same type.

A post-launch notification should be provided no more than forty-eight hours after the launch and should include the following:

- The number of launch systems that were launched
- The date and time of the launch or launches

In implementing these provisions, the following definitions would apply:

- “Ballistic missile” means a weapon-delivery vehicle that has a ballistic trajectory over most of its flight path and is designed to counter objects located on the Earth’s surface.
- “Boost-glide missile” means a weapon-delivery vehicle that sustains unpowered flight through the use of aerodynamic lift over most of its flight path and is designed to counter objects located on the Earth’s surface. A reaction control system designed to change a vehicle’s attitude is not considered capable of powering flight.
- “Extrapolated apex” means the apex of a missile defense interceptor’s or target missile’s trajectory should neither interception nor self-destruction occur.
- “Extrapolated impact point” means a missile defense interceptor’s or target missile’s impact point should neither interception nor self-destruction occur.
- “Missile defense interceptor” means a weapon that is designed to counter ballistic missiles or boost-glide missiles or their elements in flight.
- “Launch system” means a space launch vehicle, ballistic missile, boost-glide missile, missile defense interceptor, or target missile.
- “Target missile” means any vehicle launched during a missile defense test that is used as the target for an interceptor.
- “Ocean quadrant” means a ninety-degree sector encompassing approximately one-fourth of the area of the ocean.

- “Space launch” means a rocket launch for the purpose of delivering an object into outer space, Earth orbit, or a sub-orbital trajectory with a planned apex altitude greater than 500 kilometers.

If a launch system meets the definitions for both a missile defense interceptor and a ballistic missile or boost-glide missile, then, for notification purposes, it should be classified as a ballistic missile or boost-glide missile if its intended target is located on the Earth’s surface, and otherwise as a missile defense interceptor.

Verification

A verification system would not be needed for this proposal. In fact, this proposal is valuable precisely because Russia and the United States have sophisticated capabilities to detect missile and space launches and China is rapidly acquiring them, creating the risk of a launch being detected and misinterpreted.

Assessment

Technical feasibility. This proposal should be straightforward to negotiate and implement. The one required innovation would be a mechanism for China and the United States to exchange notifications.

Political feasibility. Through their participation in existing launch notification regimes, China, Russia, and the United States have all recognized the risks of escalation as a consequence of a misinterpreted test or space launch. This proposal would benefit each state by closing a number of significant gaps in those regimes.

The political obstacles facing this proposal are relatively small—at least compared to other concepts for engaging China—since no limits would be placed on any capabilities or activities. Nonetheless, when it comes to trilateral arms control, even relatively small barriers are large in absolute terms, primarily because of the poor state of U.S.-Chinese relations.

First, both China and the United States are more concerned about deliberate aggression than they are about inadvertent escalation, increasing the difficulty of generating political traction. Yet both states have recognized the possibility that escalation may not be deliberate; for example, they both participate in the 2014 Code for Unplanned Encounters at Sea, which aims to reduce the risks associated with ships operating in proximity to one another. An even more relevant precedent was set when China announced its missile tests in advance during the 1995–1996 Taiwan Strait Crisis.⁹⁵

Second, even if Beijing does not object to the principle of providing launch notifications to Washington, it may fear that doing so will lead to more pressure to engage in further arms control steps. Meanwhile, domestic critics in the United States may not view a launch notification regime as a meaningful step toward the goal of limiting China's nuclear forces. Ultimately, however, decisionmakers in each state should ask themselves whether the proposed regime would, in itself, enhance their state's security; if it would, they should support it, even if they disagree about future steps. After all, U.S. participation would not reduce Washington's leverage to push for further steps, and Chinese participation would not reduce Beijing's ability to resist them.

Finally, there may be concern that notifications could cue additional espionage activities, such as pre-positioning intelligence assets, to monitor launches. This concern is likely to be most acute in Beijing because of its distrust of the United States and because it can currently avoid notification requirements, pursuant to its agreement with Russia, by launching away from Russia or by invoking an exemption permitted in "special cases."⁶ However, even Moscow and Washington may have concerns about the increase in transparency compared to their existing bilateral regime.

That said, the warning afforded by launch notifications would not significantly enhance the effectiveness of intelligence-collection activities. China, Russia, and the United States already have, or are acquiring, early-warning satellites, which can continuously monitor launches. Similarly, visual reconnaissance satellites are likely to observe test preparations, even though the coverage they provide is episodic. Participants could try to take advantage of a launch notification by pre-positioning ships or aircraft. However, for safety reasons, tests over the ocean are generally preceded by safety warnings already. Meanwhile, aircraft are unlikely to be able to get close enough to monitor a test over land without violating other countries' airspace.

PROTECTING THE VALUABLES: ESTABLISHING KEEP-OUT ZONES AROUND HIGH-ALTITUDE SATELLITES

MILITARY COMMUNICATION and early-warning satellites in high-altitude orbits play critical roles in enabling nuclear operations—so much so, in fact, that they might be attacked as a prelude to a nuclear strike. However, threats to space-based nuclear C3I capabilities could also arise unintentionally. States periodically reposition their satellites to optimize their performance. If repositioning brought a satellite into proximity with one involved in nuclear operations, it could be misconstrued as preparation for an attack against the latter—especially in a crisis or conflict. To make matters worse, many—perhaps all—satellites involved in nuclear operations are dual-use. As a result, in a conventional conflict, they might be attacked in an attempt to disrupt nonnuclear operations being conducted by their possessor. Such attacks, however, would have the effect of degrading the target state's nuclear C3I system.

Inadvertent threats to, and attacks on, space-based nuclear C3I capabilities would not be preparations for a nuclear war, but they could risk being interpreted as such—potentially sparking catastrophic escalation.⁹⁷ In fact, the United States has threatened to resort to nuclear use should its nuclear C3I system come under attack.⁹⁸ China and Russia are probably less reliant on satellites than the United States for nuclear C3I. Even so, attacks by the United States, or even perceived preparations for them, against any Chinese or Russian satellites involved in nuclear operations would still be very provocative—especially if the target were Russia's early-warning satellites, given its launch-under-attack posture.⁹⁹

The American and Russian nuclear C3I systems, and perhaps the Chinese system too, use satellites in two different kinds of high-altitude orbits: geostationary and Molniya.

Geostationary satellites remain above a fixed point on the Earth's equator at an altitude of roughly 36,000 kilometers (22,000 miles). The United States uses this orbit for communication satellites involved in nuclear operations (all of which are dual-use).¹⁰⁰ An object in a

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Molniya orbit (a type of highly elliptical orbit) hangs above the Northern Hemisphere at altitudes approaching 40,000 kilometers (25,000 miles) before it quickly traverses the Southern Hemisphere at much lower altitudes. Russia's early-warning satellites are located in such orbits.¹⁰¹ Its Unified Satellite Communication System (which is likely used for both nuclear and conventional operations) and the United States' space-based early-warning system (which is

definitely dual-use) comprise satellites in both geostationary and Molniya orbits.¹⁰² Less is known about the Chinese nuclear C3I system. Various Chinese military communication satellites and at least one possible early-warning satellite operate in geostationary orbit—though it is not known for sure whether any are involved in nuclear operations.¹⁰³

To varying degrees, China, Russia, and the United States have developed, tested, and deployed weapons that are designed, or could be used, to attack satellites.¹⁰⁴ The difficulty of attacking satellites increases with altitude. As a result, two of the technologies that pose acute threats to satellites in low-altitude orbits would likely be much less effective against objects in geostationary or Molniya orbits. For the foreseeable future, ground-based directed-energy weapons, which focus energy on a target with, for example, a laser, will simply not be powerful enough to threaten satellites at high altitudes by damaging their sensors or other components.¹⁰⁵ Ground-based direct-ascent missiles designed to destroy satellites kinetically could prove somewhat more effective, but because their launches could be detected by a state with space-based early-warning sensors and they require hours to reach high altitudes, potential targets might have time to maneuver and thus evade an incoming interceptor.

In contrast to ground-based weapons, space-based weapons present a significant threat against high-altitude satellites today. So-called co-orbital weapons (sometimes called space mines) would be launched well in advance of any attack and dwell in an orbit that would enable them to reach potential targets relatively quickly. If activated by their possessor, they could then attack other satellites—either by colliding with them or by using a kinetic or nonkinetic standoff weapon. Such attacks could occur more quickly and would be more difficult to detect than operations involving ground-based direct-ascent weapons. Many objects could be used as co-orbital weapons, including some satellites that were not designed for that purpose.¹⁰⁶

No destructive anti-satellite testing has been undertaken against satellites in high-altitude orbits. However, in the last decade, a number of geostationary satellites have been closely

approached by others—including by Chinese, Russian, and U.S. satellites.¹⁰⁷ These operations may have been explicit demonstrations or tests of an anti-satellite capability, but even if they were not, they demonstrate that such a capability is an inherent consequence of a satellite's possessing a high degree of orbital maneuverability. The U.S. Defense Intelligence Agency assesses, for example, that “China is developing sophisticated on-orbit capabilities, such as satellite inspection and repair, at least some of which could also function as a weapon.”¹⁰⁸

Reducing the threat posed by co-orbital weapons to satellites in geostationary and Molniya orbits would mitigate the danger of inadvertent nuclear escalation. Unfortunately, efforts to establish effective arms control in space—or even to build consensus on what constitutes unacceptable behavior—have largely stalled in multilateral fora.¹⁰⁹ A trilateral approach focused on high-altitude orbits may be a fruitful way forward. It would bypass the complexities of multilateral diplomacy and focus on preventing the serious and shared danger of nuclear war.

Solution Concept

Establishing keep-out zones around high-altitude satellites could help reduce the vulnerability of key nuclear C3I capabilities. Specifically, China, Russia, and the United States should commit not to maneuver their satellites within an agreed minimum distance—700 kilometers (430 miles) in any direction—of another participant's high-altitude satellites (with the exception of repositioning maneuvers conducted one at a time and declared in advance). This agreement would apply only to satellites nationally owned by China, Russia, and the United States and not to privately owned satellites or to satellites owned by other states (so would not contravene the 1967 Outer Space Treaty's prohibition on “national appropriation”).

Currently, the regulation of high-altitude satellite orbits is minimal. The International Telecommunication Union (ITU), a United Nations agency, allocates slots to geostationary broadcast and communication satellites in order to prevent interference—though these slots can overlap if satellites operate on different frequencies or broadcast to non-contiguous regions on the ground. Participation in the ITU is voluntary and is designed only to minimize broadcast interference.

Establishing keep-out zones would go further than the ITU rules by applying to all Chinese, Russian, and U.S. satellites in both geostationary and Molniya orbits—not just geostationary satellites broadcasting at a particular frequency band—without permitting any overlap. It would begin to establish rules of the road for good behavior in space and help break the deadlock in improving space governance. Even recognizing that keep-out zones could not physically prevent one participant state from attacking another's satellites in conflict—although the proposed agreement would still apply then—they would still help to reduce escalation risks in three ways.

First, keep-out zones would mitigate the danger that repositioning operations could lead one state to wrongly conclude that one or more of its satellites were under attack—that is, the zones would help to define the difference between innocuous and aggressive actions in space. Even (or perhaps especially) in a conflict, a state that did not intend to attack a nuclear C3I satellite belonging to its adversary would have a clear incentive to abide by rules designed to prevent such threats from arising inadvertently.

Second, even if one participant decided to attack another’s satellites—for whatever reason—keep-out zones could buy time. An attacking satellite would typically have to close in on a target before launching an attack (how close it would need to come would depend on its capabilities).¹¹⁰ This process would not be instantaneous. If the target state detected a violation of its keep-out zones before the attacking satellites were able to execute the attack, it could take preventative action (by, for example, maneuvering its satellites away from the attacking ones). Increasing the warning time of an intentional attack would also reduce the likelihood of escalation resulting from time pressure.

The margin of warning afforded by keep-out zones would depend, in part, on their size. Fuel-efficient maneuvers in geostationary orbit to cross from the edge to the center of a 700-kilometer keep-out zone would require about one day (see appendix B for more details). Faster crossing would be possible by using larger amounts of fuel. For example, the same keep-out zone could be crossed in six hours by expending the same amount of fuel that a communication satellite typically uses each year for station keeping (that is, making minor adjustments so the satellite remains in its correct orbit during day-to-day operations). Larger keep-out zones would buy more warning time and further complicate attacks—but they would be more disruptive to satellite operations. The keep-out distance of 700 kilometers proposed here aims to strike a balance between increasing warning and reducing disruption.

Third, each state could use negotiations to underscore to the others the dangers of attacking its high-altitude satellites. Such messaging could reduce the likelihood of one participant’s deliberately attacking another’s dual-use satellites in an effort to win (or at least not lose) a conventional war because it had underestimated the consequent risk of nuclear escalation.

KEEP-OUT ZONES FOR SATELLITES IN GEOSTATIONARY AND MOLNIYA ORBITS

China, Russia, and the United States should make a joint political commitment that each will maintain a minimum separation between its satellites and the satellites in geostationary or Molniya orbits that belong to, and have been declared by, other participants of the agreement.

Specifically, they should agree not to maneuver any satellite into the keep-out zone of another participant's satellite:

- The keep-out zone of a satellite in geostationary or Molniya orbit should be a sphere with a radius of 700 kilometers.
- If two satellites belonging to different participants have established different Molniya orbits but are expected to pass within 700 kilometers of one another, neither participant should be required to alter the orbit of its satellite, but each should notify the other of the conjunction at least twenty-four hours before the distance between them is due to become smaller than 700 kilometers.

Repositioning maneuvers that bring one satellite into the keep-out zone of a satellite belonging to another participant should be permitted only if the participant conducting the maneuver takes the following steps:

- Notifies the other participant at least twenty-four hours before the satellite being repositioned reaches the edge of the other satellite's keep-out zone.
- Maintains a minimum distance of 250 kilometers (160 miles) between the two satellites at all times.¹¹¹
- Minimizes, to the extent possible, the time the satellite being repositioned spends in the keep-out zone of the other satellite.
- Brings no more than one satellite at a time into any of the keep-out zones of the satellites belonging to each of the other participants.

The participants should annually exchange confidential lists of state-owned satellites in geostationary and Molniya orbits. Only satellites included on this list should be entitled to keep-out zones.

- For each satellite registered with the United Nations Register of Objects Launched into Outer Space, its owner should provide its international designator.
- For any other satellite, its owner should provide a designator and its basic orbital parameters (in accordance with the provisions of the United Nations Register of Objects Launched into Outer Space).

By notifying the other participants, each participant may register on or remove from the list a satellite at any time.

The participants should hold an annual meeting to discuss any compliance or implementation issues. They should also commit to discussing urgent compliance concerns through regular diplomatic channels.

Implementing this proposal in geostationary orbit—where one satellite would essentially have to tail another to approach it—would be relatively straightforward. Two satellites in quite different Molniya orbits, however, may occasionally happen to pass close to one another, creating a complication. Because each participant is equally responsible for such a conjunction, there would be no obvious way of deciding which participant should be required to take action to avoid it. For this reason, there should be no requirement to do so, though each participant should be required to inform the other of the impending approach. In any case, conducting an attack during one of these rare conjunctions would be technically difficult since the relative velocities of the satellites involved can be very large.

To ease implementation, only declared satellites should be afforded the protection of a keep-out zone. But because all the participants’ nationally owned satellites, declared or not, must respect keep-out zones, controversy could arise about the ownership of a given satellite. States should commit to discussing such concerns at annual implementation meetings or, if urgent, through diplomatic channels.

Today, a small number of Chinese, Russian, and U.S. geostationary satellites are typically located within 700 kilometers of each other. To establish keep-out zones, some of these satellites would need repositioning—but this should not be onerous and would not meaningfully impact the participants’ capabilities. Table 2 shows the number of geostationary satellites that would need to be moved as of January 1, 2021, depending on the size of the keep-out ones. Zones with a radius of 700 kilometers (just under 1 degree) would only require seven satellites to be moved. Regardless, repositioning is a routine operation, and only minor orbital adjustments would be needed (though the participants would have to negotiate, on the basis of reciprocity, who would move which satellites).

TABLE 2
NUMBER OF GEOSTATIONARY SATELLITES THAT WOULD NEED REPOSITIONING TO IMPLEMENT KEEP-OUT ZONES

| Separation (degrees) | United States–Russia | Russia–China | China–United States | Total |
|----------------------|----------------------|--------------|---------------------|-------|
| 0.5 | 2 | 1 | 2 | 5 |
| 1.0 | 3 | 1 | 3 | 7 |
| 1.5 | 7 | 1 | 5 | 13 |
| 2.0 | 7 | 2 | 6 | 15 |

Source: Author calculations based on satellite data as of January 1, 2021, courtesy of Union of Concerned Scientists, “UCS Satellite Database,” January 1, 2021, <https://www.ucsusa.org/resources/satellite-database>.

Verification

Participants would verify compliance with this proposal by using their space situational awareness capabilities to periodically measure the positions of satellites in geostationary and Molniya orbits. This data—longitude, latitude, and altitude—enables not only the distance between satellites to be computed but also whether one satellite is drifting in the direction of another. A state would likely want to monitor its own satellites and those belonging to other participants. Failing to detect another participant's satellite at its expected location would be evidence that it was maneuvering and could cue a search.

Participants would presumably want to be able to observe satellites in geostationary and Molniya orbits frequently enough that, in the time between observations, a co-orbital weapon could move only, say, one-half or one-third of the distance from the edge of a keep-out zone to the satellite at its center. There can be no definitive estimate of this time period since it would depend on how much fuel is available to the attacking satellite and, of that, how much the attacker would be willing to expend. Nonetheless, ideally, each participant would probably want to image any satellites near its own every two or three hours.

There are various means to detect the positions of satellites in high-altitude orbits.¹¹² In each case, multiple sensors are required to monitor all relevant satellites. For ground-based systems, these sensors must be spread around the Earth.

- Ground-based optical sensors—telescopes—can detect satellites by observing reflected light from the sun or from a laser used to illuminate the target. They are the simplest, most inexpensive, and most readily available means to detect satellites, though they suffer from various limitations. Most notably, they cannot operate in daylight or when skies are overcast. However, commercially available infrared telescopes have proven capable of tracking geostationary satellites during the day, thus addressing a key weakness of existing optical telescopes.¹¹³
- Space-based optical sensors are capable of high-cadence imaging of other satellites, though they are considerably more expensive than ground-based telescopes. Their performance depends on the number of available sensors and their orbits.
- Ground-based radio telescopes can be used to locate satellites by intercepting their communications. Such observations are not affected by weather or time of day but are only possible when a satellite is transmitting.
- Some ground-based radars are capable of detecting and imaging high-altitude satellites. They are not affected by weather or time of day, but they are expensive and have a particularly limited field of view. They are therefore poorly suited to wide-area searches, but they can accurately measure the position of satellites whose approximate locations are known.

China, Russia, and the United States have long had an interest in developing effective space situational awareness capabilities. These capabilities are shrouded in opacity, particularly in the cases of China and Russia—though some significant inequalities are apparent. (Appendix C summarizes what is publicly known about each state’s capabilities.) For its part, the United States is likely already capable of verifying the proposed agreement—at least for most of geostationary orbit (it may lack radar coverage over parts of the Eastern Hemisphere). The opacity of Russian and Chinese capabilities makes it difficult to determine whether they could also verify the agreement. Russia has a fairly extensive space situational awareness system, though it likely has less capability than the United States. Chinese capabilities, meanwhile, are more opaque still and likely less sophisticated than Russia’s.

Feasibility

Technical feasibility. The primary technical challenge to verification is uncertainty about the adequacy of existing space situational awareness capabilities—China’s and Russia’s, in particular. (Making minor adjustments to the positions of a small number of satellites to establish keep-out zones should be straightforward, though deciding who would move which satellite could become somewhat contentious.)

Even if not all the participants have adequate verification capabilities today, however, they are likely on a trajectory to acquire them. Accurately tracking the location of highly valuable satellites—and potential threats to them—is clearly in the national interests of China, Russia, and the United States, regardless of whether they try to mitigate those threats cooperatively. Moreover, acquiring effective space situational awareness capabilities is critical to the development of anti-satellite weapons, which all three states appear to want. At the same time, cheaper ways of monitoring high-altitude satellites, such as infrared telescopes, are emerging. Any participants currently lacking the required verification capabilities might still be able to detect noncompliance, albeit without high confidence.

Political feasibility. One key political challenge is that China and Russia appear to want the ability to hold U.S. satellites in high-altitude orbits at risk, while the United States may desire a similar capability against China and Russia. These incentives are probably asymmetric right now as the U.S. military relies more heavily on satellites, which could present tempting targets for China and Russia during a conflict.

But the incentives may be evening out. China and Russia are investing heavily in military satellites, including in high-altitude orbits. Notably, Russia is rebuilding its space-based early-warning system and has offered assistance to China, which is developing one for the first time.¹¹⁴ Russia relies on a launch-under-attack policy to help ensure the survivability of its nuclear forces, while China appears to be moving in the same direction. While both states also have a network of ground-based early-warning radars, they should seek (as the

United States does) to have confirmation of an incoming attack from two physically independent detection systems before deciding to launch their nuclear forces.

Furthermore, while attacks on high-altitude satellites could provide military benefits, they could also create serious risks. In fact, because they could undermine nuclear C3I capabilities, they would be even more escalatory than attacks on satellites orbiting at lower altitudes (which would hardly be risk-free). As a result, an agreement that focuses narrowly on enhancing the survivability of satellites in geostationary and Molniya orbits—and thus reduces the shared risk of nuclear war—may be of interest to Beijing, Moscow, and Washington.

APPROACHING THE THIRD RAIL? A TRILATERAL TREATY TO PROHIBIT SPACE-BASED MISSILE DEFENSES

OVER THE PAST few years, the United States has restarted its efforts to develop space-based missile defenses. In 2018, the U.S. Congress directed the Department of Defense to identify potential technologies for, and to estimate the costs of, deploying a space-based missile defense layer.¹¹⁵ Research into space-based defenses was funded throughout the remainder of the Trump administration.¹¹⁶ Given their absence from the Biden administration's Fiscal Year 2021 budget request, their short-term future is less clear—although, over the long term, the United States is likely to remain interested in them, while China and Russia are likely to remain concerned about them.

Space-based missile defenses—involving kinetic interceptors or nonkinetic technologies, such as directed-energy weapons—are capable, at least in theory, of addressing some of the weaknesses of terrestrial missile defense systems. For example, the United States' Ground-based Midcourse Defense system is vulnerable to decoys deployed in the vacuum of space or to hypersonic gliders that fly below the interceptors' engagement altitude. Space-based defenses could overcome such countermeasures by engaging a missile in its boost phase, while its engines are still operating and before decoys can be deployed or a glider released. Alternatively, space-based defenses could be configured to intercept ballistic missiles during their midcourse phase when they are unpowered. In particular, directed-energy weapons offer the potential to engage large numbers of incoming warheads (and decoys).

Chinese and Russian officials have repeatedly expressed concerns over existing and possible future U.S. ballistic missile defenses. Russia's developmental exotic weapons are intended to circumvent them. Because some of these weapons—the Burevestnik cruise missile and Poseidon torpedo, in particular—could evade space-based interceptors, concerns that the United States may develop and deploy space-based defenses could make Russia less amenable to limits on its exotic systems. U.S. officials, meanwhile, have claimed that China

Space-based missile defenses present daunting technical challenges and are likely to be extraordinarily expensive.

is “looking at” nuclear-powered cruise missiles and torpedoes, perhaps because many of its existing programs to combat U.S. missile defenses—including arming missiles with multiple warheads and developing an intercontinental hypersonic glider—could theoretically be vulnerable to space-based defenses.¹¹⁷

These concerns may also lead China and Russia to deploy anti-satellite weapons in even larger numbers than currently planned to ensure that they are able to target the satellites on which interceptors would be based or the sensors that would enable them. Such deployments, even if undertaken solely to combat missile defenses, would increase the threat to all U.S. assets in low-Earth orbit.

Space-based missile defenses could also create significant escalation pressures for two reasons. First, to be most effective, attacks on space-based missile defenses would need to occur in advance of a nuclear exchange. Thus, if Russia, say, perceived an impending attack against its nuclear forces, it might attack space-based interceptors or their enabling capabilities preemptively (assuming, that is, that those enabling capabilities, which would include dual-use early-warning sensors, had not already been attacked during the preceding phases of the conflict). Second, space-based interceptors themselves could be used as anti-satellite weapons and thus be attacked, potentially quite early in a conflict, as a way to protect the satellites used to support conventional operations.

In addition to these risks, space-based missile defenses present daunting technical challenges and are likely to be extraordinarily expensive. To engage ballistic missiles during their boost phase, a space-based missile defense system would need to be designed so that interceptors were always located relatively close to all potential missile launch sites. Because satellites in low-Earth orbit are in constant motion relative to the Earth's surface, hundreds of platforms—close to a thousand, in fact, for global coverage—would be needed.¹¹⁸ Because missiles could be safely fired during any gaps in coverage, which all participants have the space awareness capabilities to identify, space-based defenses would likely have no meaningful capability at all until hundreds of interceptors had been placed in orbit.¹¹⁹ Moreover, to combat missile volleys, each platform would need to be capable of engaging multiple targets in quick succession.

The development of a space-based system designed to intercept missiles during the mid-course phase of their flight would be somewhat less demanding—though still extremely difficult—because only tens of satellites might be required.¹²⁰ However, such a system would also be less effective since incoming ballistic missiles would have a chance to release multiple warheads, decoys, and other countermeasures, and incoming gliders might have dropped below the minimum engagement altitude. Moreover, the kinds of high-powered, low-weight lasers and power supplies that could make such a system even remotely plausible are still a long way from being developed.¹²¹

As a result, the United States is unlikely to ever deploy a meaningful space-based missile defense capability. Nonetheless, its investments in technology development will continue to spur China and Russia to develop countermeasures. This is the central irony of space-based missile defense systems: the United States is likely to pay a significant political and strategic price for a system from which it will never benefit.

Solution Concept

A trilateral prohibition on the testing and deployment of any space-based weapons designed to counter ballistic or boost-glide missiles would provide a verifiable means to manage concerns about space-based defenses. It would apply to all such weapons—kinetic or nonkinetic—but would not affect the deployment of space-based sensors to detect missile launches or track missiles during flight. Such a ban would not require any state to forsake a capability that it was remotely likely to deploy but would lessen Chinese and Russian incentives to develop or retain potentially destabilizing countermeasures, such as exotic strategic capabilities and sophisticated anti-satellite capabilities.

In theory, a state would need to overcome two major hurdles to deploy a useful space-based missile defense system. First, space-based interceptors would need to be tested under realistic conditions—that is, launched from orbit to engage targets in the atmosphere. Without testing, space-based missile defenses would probably be highly ineffective. Indeed, the United States' experience with its Ground-based Midcourse Defense system highlights the challenges of obtaining reliability even after more than two decades of testing.¹²² Second, hundreds or thousands of interceptor platforms would need to be built and launched into orbit, requiring many dozens, if not hundreds, of launches—which is well beyond the ability of any of these countries to conduct in a limited time with current launch resources.

Although prohibiting either testing or deployment would be enough to prevent

The United States is unlikely to ever deploy a meaningful space-based missile defense capability. Nonetheless, its investments in technology development will continue to spur China and Russia to develop countermeasures.

the development of reliable space-based missile defenses, the proposed prohibition covers both, while relying on NTM for verification. The proposed fifteen-year time horizon, with an option to extend the agreement in five-year increments, represents a potential compromise between the United States (which would likely prefer a politically binding agreement) and China and Russia (which would presumably prefer a treaty with no expiration provisions).

A PROHIBITION ON THE TESTING AND DEPLOYMENT OF SPACE-BASED MISSILE DEFENSE WEAPONS

China, Russia, and the United States should conclude a treaty prohibiting the testing or deployment of space-based missile defense weapons for fifteen years, with the option of extending the agreement in five-year increments by mutual consent.

Specifically, the parties should agree to prohibit the following:

- The testing of space-based missile defense weapons
- The deployment of space-based missile defense weapons in orbit

In implementing these provisions, the following definitions would apply:

- “Space-based missile defense weapon” means any weapon, based on any physical principle, that is located in Earth orbit and designed to counter ballistic missiles or boost-glide missiles or their elements in flight trajectory.
- “Ballistic missile” means a weapon-delivery vehicle that has a ballistic trajectory over most of its flight path.
- “Boost-glide missile” means a weapon-delivery vehicle that sustains unpowered flight through the use of aerodynamic lift over most of its flight path. A reaction control system designed to change a vehicle’s attitude is not considered capable of powering flight.

The parties should hold an annual implementation meeting to discuss compliance or implementation issues. They should also commit to discussing urgent compliance concerns through regular diplomatic channels.

Verification

The prohibition would be verified through NTM, with efforts primarily focused on assessing compliance with the ban on testing.

Preparations for the launch of a target missile could be monitored with satellite imagery and potentially other information-collection techniques (including signals and human intelligence). Such preparations would probably not constitute definitive evidence of noncompliance since it would likely be unclear whether the planned test was of a prohibited space-based missile defense weapon, but they could cue enhanced intelligence-gathering efforts.

The test itself would present various opportunities for detection, depending on whether the missile defense weapon was kinetic or nonkinetic and at what point in its trajectory the target missile was engaged. In all cases, the launch of the target missile could be monitored with early-warning satellites. For a successful boost-phase engagement, the target missile's plume (ejected hot gasses that are the source of intense infrared radiation that can be detected by satellites) would presumably be rapidly and prematurely extinguished.

Space situational awareness capabilities could also be useful for verification. They might be capable of detecting the launch of kinetic interceptors or the debris resulting from an engagement, especially during the midcourse of a target's trajectory. In theory, ground-based sensors, such as radars, could be used. In practice, space-based sensors, which provide continuous coverage, would likely be more useful. (The benefits and limitations of different space situational awareness technologies are discussed in appendix C.)

Telemetry—the data transmitted from the target missile and the missile defense weapon for diagnostic purposes—could also be useful in detecting a test. Such signals could be intercepted with electronic-intelligence satellites or ground-based radars. Even if they were encrypted, as seems likely, their existence would still be evidence of a prohibited test.

The biggest verification challenge might be that a state could try to test space-based missile defense weapons against other satellites rather than against target missiles. However, a state would have little incentive to do so. First, this approach would risk creating a significant quantity of orbital debris that could threaten the state's own satellites. Second, testing missile defense weapons against satellites would not contribute much to the development of boost-phase defenses. It would be more helpful in the development of midcourse defenses—but because reentry vehicles are likely more resilient than satellites and would likely be comingled with decoys and booster debris, the development of a reliable midcourse missile defense capability would probably require additional tests against target missiles under more realistic conditions.¹²³

Ultimately, to gain a meaningful operational capability, a state would need to conduct a lengthy testing campaign, requiring significant resources and personnel. Such a campaign would be difficult to conceal against multiple intelligence-collection techniques (technical and human), even if the state sometimes managed to hide individual tests.

The deployment of space-based ballistic missile defenses could also be monitored with NTM—though here the need to distinguish prohibited space-based interceptors from

permitted space-based anti-satellite weapons (or perhaps even permitted space-based ground-attack weapons) could arise. Helpfully, the deployment pattern of a boost-phase space-based missile defense system should be very distinctive. A high degree of coverage and redundancy would be needed to gain any value from such a system. Thus, the deployment of large numbers of weapon-carrying satellites in orbits that provide continuous coverage of potential missile launch sites would provide fairly clear evidence of a state's intentions—and could be easily detected—even if the exact capabilities of the weapons on any given platform were ambiguous.

Distinguishing between a midcourse space-based missile defense system, which could involve tens of satellites, and space-based anti-satellite weapons could be more difficult (which is partly why the prohibition on testing presents the best opportunity for assessing compliance). Yet deploying either system would require a major and prolonged effort,

Any illicit program to develop space-based missile defenses would have to be large-scale, complex, and prolonged, providing plenty of opportunities for detection.

potentially yielding intelligence to help understand that state's intent. Moreover, as already noted, midcourse space-based missile defense systems are unlikely to be technologically feasible within the lifetime of the proposed agreement and would, in any case, be significantly less effective than boost-phase systems.

Feasibility

Technical feasibility. The proposed treaty should be straightforward to negotiate, largely because it would rely on NTM for verification. Its technical feasibility would therefore hinge on each state's national capabilities. At least four types of NTM capabilities besides human intelligence could be useful: electronic-intelligence collection, space-based reconnaissance, space situational awareness, and missile launch detection.

Electronic-intelligence collection capabilities and, to a slightly lesser extent, visual reconnaissance satellites are shrouded in secrecy. Publicly available information about each state's space situational awareness capabilities is discussed in appendix C. This information suggests that the United States' capabilities are sufficiently sophisticated and persistent to be of considerable use in verifying the proposed prohibition on testing. Chinese and Russian capabilities are likely less sophisticated but could play a meaningful role nonetheless, though there is more uncertainty here.

In terms of missile launch detection, the U.S. space-based early-warning system would allow the United States to reliably monitor the launch of any test target (and possibly even the launch of any space-based kinetic interceptors). Russia is currently rebuilding its space-based monitoring capability; with the launch of a fourth satellite in 2020, its new system

reached its “minimum baseline configuration,” suggesting it “can ensure round-the-clock coverage of the most critical areas.”¹²⁴ China may not yet have a comprehensive space-based early-warning system, though the U.S. Department of Defense assesses that it is now developing one, potentially with Russian assistance.¹²⁵

Altogether, the various known and unknown potential weaknesses in each state’s NTM capabilities should not prevent effective verification—simply because any illicit program to develop space-based missile defenses would have to be large-scale, complex, and prolonged, providing plenty of opportunities for detection. To be sure, U.S. capabilities are more sophisticated than Russia’s or China’s (though theirs are improving), but the United States would face particularly significant challenges in secretly pursuing a program of the required scale and complexity.

Political feasibility. Russia and China would likely support this proposal. Neither have shown any interest in developing space-based missile defenses, and they view the United States’ potential deployment of such a system as a serious threat. Indeed, Beijing and Moscow have recently invoked the specter of U.S. space-based missile defenses to help argue for a treaty—which they have jointly proposed—that would prohibit the placement of weapons in outer space.¹²⁶

The primary political impediment to the prohibition on space-based missile defenses proposed here would be resistance within the United States, where there is strong domestic support for missile defenses. Space-based missile defense programs have had a constituency since president Ronald Reagan’s Strategic Defense Initiative of the 1980s.¹²⁷ While support for such programs today is less broad than for many other missile defense technologies, these programs still have vocal supporters, including in Congress, who invoke them as a potential route to invulnerability from a missile attack.¹²⁸

For this reason, it could be difficult for the U.S. administration to obtain the Senate’s advice and consent for ratification of the proposed treaty. A politically binding executive agreement would be easier to obtain, of course, but would also be much less valuable to China and Russia, reducing their willingness to grant the United States significant concessions in return. (However, if U.S. policymakers consider a treaty to be totally infeasible, they could explore a joint political commitment or even coordinated unilateral moratoria.)

One feature of the proposed treaty that would help lessen domestic resistance in the United States is that it would only last fifteen years (with an extension option). Although Beijing and Moscow would presumably prefer an indefinite agreement, a time-limited treaty could help address U.S. concerns about the possibility that technological developments might increase the need for, or enhance the feasibility of, space-based missile defenses.

Another reason for considering a treaty is that limitations on space-based interceptors may be at least somewhat more palatable for the United States than limitations on ground-based

missile defenses (which attract particularly intense domestic opposition). Support for developmental capabilities is never as strong as support for existing capabilities. Moreover, the costs associated with deploying space-based defenses are likely to be prohibitive for the foreseeable future. The United States has barely scratched the surface of the needed research and development investments, and the large number of interceptor platforms that would need to be deployed for a system to be at all useful would be exorbitantly expensive.

Finally, if China and Russia want a prohibition of space-based missile defenses, they will have to make significant concrete concessions to the United States in return. One approach would be to package the proposed prohibition with separate U.S.-Russian and U.S.-Chinese measures that were similarly time-bound. For example, Russia and the United States could agree to a strategic offensive arms control treaty that included significant limits on Russia's exotic delivery systems (which are intended to defeat U.S. missile defenses). Meanwhile, China and the United States could agree to a bilateral fissile material cutoff because, with more clarity about the future trajectory of U.S. missile defenses, Beijing might be willing to commit to refraining from producing any new fissile material for military purposes (see chapter 4). Of course, this kind of triangular diplomatic dance could be difficult to orchestrate and, in practice, negotiators would need to capitalize on the trade-offs that seem attainable at the time.

CHAPTER 8

A COMPREHENSIVE APPROACH: A TRILATERAL TREATY TO LIMIT MISSILE LAUNCHERS AND BOMBERS

CHINA, RUSSIA, AND THE United States are engaged in a costly missile race that fuels tensions and increases the risk of nuclear escalation during a conventional conflict. Russia's and the United States' strategic forces will continue to be limited, at least until February 2026 when New START expires. However, the demise of the INF Treaty has opened the door to competition in ground-launched missiles with ranges between 500 kilometers (310 miles) and 5,500 kilometers (3,400 miles). In response to the United States' withdrawal from the treaty, Putin announced that Russia would develop a ground-launched version of the Kalibr SLCM—which is, in fact, what the SSC-8 is believed to be—and a ground-launched hypersonic missile.¹²⁹ The United States, meanwhile, is developing a number of conventional ground-launched missiles, including a variant of the Tomahawk cruise missile, a surface-attack variant of the SM-6 air-defense missile, a new tactical ballistic missile, and a hypersonic boost-glide weapon.¹³⁰

Countering China's large and growing force of regional missiles was one important rationale behind the United States' decision to leave the INF Treaty.¹³¹ China has deployed seven types of ground-launched ballistic, boost-glide, and cruise missiles with ranges between 500 and 5,550 kilometers (some of which are produced in multiple variants).¹³² Three of these missiles—the DF-21 and DF-26 ground-launched ballistic missiles and the DF-17 ground-launched boost-glide missile—are known or believed to be dual-use. Beijing views the United States' development of new ground-launched missiles with concern and may in-

crease its own stockpile of such missiles to maintain its large numerical advantage.¹³³ China is also modernizing and expanding its strategic nuclear forces, which are not restricted by any arms control agreement, though are significantly smaller than the corresponding Russian and U.S. arsenals.

Looking forward, this trilateral arms race could intensify, including through the development of new ground-launched missiles capable of delivering nuclear and nonnuclear warheads accurately over ever longer ranges. Intensified quantitative arms racing is another risk—especially if Russia and the United States are unable to negotiate a replacement to New START—with potentially far-reaching consequences. If China perceives that a U.S. buildup increases the threat to its nuclear forces, it may accelerate its program to expand those forces (which, in turn, could have implications for India and hence Pakistan).

Developments in aircraft and air-delivered weapons are less competitive, though still significant. New START limits heavy bombers, defined as aircraft with a range in excess of 8,000 kilometers (5,000 miles) or that are equipped for long-range, nuclear-armed air-

launched cruise missiles. However, the development of increasingly capable air-launched missiles is threatening to confer similar capabilities on aircraft that are not accountable under New START. For example, there is concern in the United States that Russia may deploy Kinzhal, a dual-use air-launched ballistic missile with a claimed range of up to 2,000 kilometers (1,200 miles), on its Tu-22M (Backfire) medium bomber—enabling that aircraft to conduct nuclear or precise conventional strikes over

Looking forward, this trilateral arms race could intensify, including through the development of new ground-launched missiles capable of delivering nuclear and nonnuclear warheads accurately over ever longer ranges.

distances currently within reach of heavy bombers only.¹³⁴ China, meanwhile, has developed an air-launched ballistic missile for its H-6N bomber that “may be nuclear capable.”¹³⁵ (It is unclear whether China’s current bomber meets the definition of a heavy bomber and whether its developmental stealth bomber will do so, but it is also moot given that China is not a party to New START.)

These developments could also increase the danger of escalation. In particular, Beijing and Moscow appear to worry that, in a crisis or conflict, highly accurate U.S. conventional missiles might be used to attack their nuclear forces or military or national leadership with little warning. (Indeed, Moscow worried that the nuclear-armed U.S. Pershing II intermediate-range ballistic missiles deployed to Europe in the 1980s could be used for exactly that purpose.) This concern has been exacerbated by U.S. deployments of missile defense interceptors, which China and Russia fear could be used to intercept any nuclear missiles that survived a U.S. first strike and were fired in retaliation. In a crisis or conflict, this set of

fears could prompt China or Russia to launch preemptive attacks on U.S. ground-launched missiles (ideally before their dispersal), missile defense assets, or their associated enabling capabilities. In extremis, it could even add to the pressures on China or Russia to make nuclear threats or to initiate nuclear first use.

In fact, for Russia in particular, concerns about counterforce attacks and missile defense operations are intertwined because of the United States' deployment of SM-3 interceptors at Aegis Ashore sites (see chapter 3). Russian officials have expressed concerns that these interceptors could be rapidly converted into ground-attack ballistic missiles. They have also highlighted the possibility of Aegis Ashore launchers being used to fire cruise missiles. U.S. statements that those launchers lack that capability do not appear to have assured Russia, which points to the 2019 test launch of a cruise missile from a land-based MK-41 Vertical Launching System, from which the Aegis Ashore system is derived.

Solution Concept

Limits on missiles and aircraft could be useful in managing these dangers. They could help to prevent arms racing and mitigate escalation risks by curtailing the threat posed to military and national leadership, and to nuclear forces and their enabling capabilities. Depending on precisely which capabilities were limited, however, agreements could be extremely complex to negotiate and verify—difficulties that would be compounded by the involvement of three parties.

A *relatively* simple approach, based on an idea by Zhao, would be for China, Russia, and the United States to agree to a single limit on all missile launchers and aircraft that were limited under the INF Treaty or are limited by New START, along with a few other closely related types.¹³⁶ Such an agreement would build directly on past experience and complement—not replace—the limits on Russian and U.S. strategic forces imposed by New START or any successor treaty.

The trilateral treaty proposed here would cover three specific categories of weapons:

- Launchers for ground-launched cruise missiles, ground-launched ballistic missiles, and ground-launched boost-glide missiles with ranges over 475 kilometers (295 miles)
- SLBM launchers
- Bombers with ranges greater than 2,000 kilometers

Each accountable launcher and each accountable bomber would count as one unit, irrespective of whether it was armed with nuclear or nonnuclear armaments (or, indeed, was unarmed) and whether or not it was deployed. Warheads and missiles would not be limited.

However, because missiles and warheads are not militarily useful without launchers, this approach would impose a meaningful limitation on the parties' overall conventional and nuclear capabilities.¹³⁷ It would also enhance the proposed agreement's feasibility. Limiting launchers, rather than smaller items like warheads or missiles, would reduce verification difficulties significantly. The first U.S.-Soviet arms limitation treaties—the Strategic Arms Limitation Talks (SALT) I Interim Agreement and the never-ratified SALT II Treaty—focused on launchers largely for this reason.

Underlying the proposed agreement would be a key compromise. In a major concession to China and Russia, the United States would agree that, for the purposes of treaty implementation, its Aegis Ashore launchers met the definition of a launcher for ground-launched cruise missiles and were thus accountable. This provision should help to manage Chinese and Russian concerns about the possible future growth of U.S. missile defense capabilities. Meanwhile, in a major reciprocal concession to Washington, Beijing and Moscow would agree that the treaty should not constrain SLCMs or future SLBGMs—an area of U.S. advantage—on the grounds that the relevant launchers typically also accommodate other types of weapons, such as air- and missile-defense interceptors and anti-submarine weapons.

To facilitate this compromise, the proposed treaty would exempt from accountability any SLBM launchers converted into SLCM launchers prior to its entry into force. In practice, this provision would apply only to the launchers on the United States' four SSGNs (SSBNs converted to carry cruise missiles). Pursuant to New START, Russia currently has limited rights to inspect these launchers. China, which is not a party to New START, would have to rely on verification by Russia to bolster its own NTM. While this approach would not be ideal, especially from Beijing's perspective, the problem would only be temporary since all four U.S. SSGNs are due to be retired by 2028.¹³⁸

All other launchers and bombers could be removed from accountability only after they had been permanently eliminated. Thus, the four SLBM launchers on each U.S. SSBN that were "converted" (in other words, rendered inoperative) to meet New START's central limits *would* count under the proposed treaty.

Ground-based launchers would be accountable if used to launch missiles with a range in excess of 475 kilometers. This distance—which is slightly shorter than the 500 kilometers threshold adopted in the INF Treaty—would bypass the controversy over the range of the SSC-8. The United States claims (almost certainly correctly) that this missile has a range of "well over" 500 kilometers; Russia has pegged it at 480 kilometers (300 miles).¹³⁹ The proposed treaty would address U.S. concerns without forcing Russia to acknowledge that it had violated the INF Treaty.

TABLE 3
**ESTIMATES OF CHINESE, RUSSIAN, AND U.S. ACCOUNTABLE LAUNCHERS
 AND ACCOUNTABLE BOMBERS (AS OF OCTOBER 2021)**

China^a

| Category | Missile or Bomber Type NATO Reporting Name (national designation) | Range Category (kilometers) | Number of Launchers or Bombers | Notes | Sources (see bottom of table for complete citations) |
|------------------------------|---|-----------------------------------|--------------------------------------|--|---|
| Accountable Launchers | | | | | |
| GLBMs and GLBGMs | CSS-6 (DF-15) Mods 1, 2, 3 | 475-1,000 | -250 | The DF-11 Mod 1 has a range less than 475 kilometers, but its launchers would be accountable if they have ever launched DF-11 Mod 2. | DIBMAC (2020, 21) OSD (2020, 166) |
| | CSS-7 (DF-11) Mods 1, 2 | | | | |
| | CSS-11 (DF-16) Mods 1, 2 | | | | |
| | CSS-5 (DF-21) Mods 2, 4, 5, 6 | 1,000-5,550 | -350 | | DIBMAC (2020, 25) OSD (2020, 86) |
| | CSS-18 (DF-26) CSS-22 (DF-17) | >5,500 | -100 | At least 230 new silos, likely for DF-41s, are under construction. | Broad and Sanger (2021) DIBMAC (2020, 29) OSD (2020, 166) Lee (2021) Warrick (2021) |
| GLCMs | CJ-10 (DH-10) | >475 | -100 | | DIBMAC (2020, 36) OSD (2020, 56 and 166) |
| SLBMs | CSS-N-14 (JL-2) | >600 | 48 | Two additional SSBNs are expected to enter service shortly. | DIBMAC (2020, 33) OSD (2020, 45) |
| Accountable Bombers | | | | | |
| Bombers | H-6H/M/K/N (B-6) | >2,000 | -172 | | IJSS (2021, 255) |
| TOTAL | | | -1,000 | | |

Russia^a

| Category | Missile or Bomber Type NATO Reporting Name (national designation) | Range Category (kilometers) | Number of Launchers or Bombers | Notes | Sources (see bottom of table for complete citations) |
|------------------------------|---|-----------------------------------|---|--|---|
| Accountable Launchers | | | | | |
| GLBMs and GLBGMs | SS-26 (9K720 Iskander-M) | 475-1,000 | ~144 | The SS-26 has a range less than 475 kilometers, but its launchers have launched SSC-7. | DIBMAC (2020, 21) Kristensen and Korda (2021b, 91) |
| | SS-18 Mod 5 (RS-20V) SS-19 Mod 4 (Avangard) SS-25 (RS-12M Topol) SS-27 Mods 1, 2 (RS-12M1/12M2, Topol-M, RS-24 Yars) | >5,500 | 310 | Russia also possesses a small but known number of prototype SS-28 (RS-26) launchers. | DIBMAC (2020, 29) Kristensen and Korda (2021b, 91) |
| | SSC-5 (3M-55) SSC-7 (9M728) SSC-8 (9M729) 3M-14 (and others from the Club-K system) | >475 | ≥80 | The number of launchers is very uncertain and could be much larger because of an unknown number of Club-K systems from which cruise missiles with a range in excess of 475 kilometers, including the 3M-14, have been launched. Whether the range of the SSC-5 (~60 launchers) exceeds 475 kilometers is unclear. SSC-7 launchers are counted under SS-26. | DIBMAC (2020, 36) Kristensen and Korda (2021b, 91) Rosoboronexport (2021) |
| | SS-N-18 M1 (RSM-50) SS-N-23 M1(RSM-54 Sineva) SS-N-32 (RSM-56 Bulava) | >600 | 176 | | Kristensen and Korda (2021b, 91) |
| Accountable Bombers | | | | | |
| Bombers | Backfire (Tu-22M3/22M3M) Bear-H6/16 (Tu-95MS6/95MS16/95MSM) Blackjack (Tu-160/160M) | >2,000 | ~88 | | Kristensen and Korda (2021b, 91) IISS (2021, 198) |
| TOTAL | | | >800 (possibly significantly larger) | | |

United States

| Category | Missile or Bomber Type | Range Category (kilometers) | Number of Launchers or Bombers | Notes | Sources (see bottom of table for complete citations) |
|------------------------------|--|-----------------------------|--------------------------------|---|---|
| Accountable Launchers | | | | | |
| GLBMs | - | 475-1,000 | 0 | HIMARS and perhaps M270A1 launchers are expected to launch missiles with ranges in excess of 475 kilometers in the future. | |
| | LGM-30G Minuteman III | >5,500 | 458 | | DOS (2020) |
| GLCMs | (Aegis Ashore) | n/a | 24 | Launchers are considered to be accountable for the purposes of treaty implementation because the sea-based MK-41 Vertical Launching System has launched cruise missiles with ranges in excess of 475 kilometers. Additional launchers in Poland are under construction. | LaGrone (2013) |
| SLBMs | UGM-133A Trident D5 | >600 | 336 | Converted SLBM launchers on SSBNs, but not on SSGNs, are included. | DOS (2020) Kristensen and Korda (2021 ^a , 51) |
| Accountable Bombers | | | | | |
| Bombers | B-52H Stratofortress B-2A Spirit B-1B Lancer | >2,000 | 168 | Test bombers are excluded. | DOS (2020) IISS (2021, 57) |
| TOTAL | | | 986 | | |

Key

- GLBM: ground-launched ballistic missile
- GLBGM: ground-launched boost-glide missile
- GLCM: ground-launched cruise missile
- SLBM: sea-launched ballistic missile

^a There are significant uncertainties associated with the figures for China and particularly Russia.

Sources: William J. Broad and David E. Sanger, "A 2nd New Nuclear Missile Base for China, and Many Questions About Strategy," *New York Times*, July 26, 2021, <https://www.nytimes.com/2021/07/26/us/politics/china-nuclear-weapons.html>; Department of State (DOS), Bureau of Arms Control Verification and Compliance, "New START Treaty Aggregate Numbers of Strategic Offensive Arms," December 1, 2020, <https://www.state.gov/new-start-treaty-aggregate-numbers-of-strategic-offensive-arms-15/>; Hans M. Kristensen and Matt Korda, "United States Nuclear Weapons, 2021," *Bulletin of the Atomic Scientists* 77, no. 1 (2021): 51; Hans M. Kristensen and Matt Korda, "Russian Nuclear Weapons, 2021," *Bulletin of the Atomic Scientists* 77, no. 2 (2021): 91; International Institute for Strategic Studies (IISS), *The Military Balance 2021* (London: IISS, 2021); Defense Intelligence Ballistic Missile Analysis Committee (DIBMAC), "Ballistic and Cruise Missile Threat 2020," July 2020, https://media.defense.gov/2021/Jan/11/2002563190/-1/-1/1/2020%20BALLISTIC%20AND%20CRUISE%20MISSILE%20THREAT_FINAL_2OCT_REDUCEDFILE.PDF; Rod Lee, "PLA Likely Begins Construction of an Intercontinental Ballistic Missile Silo Site Near Hangjin Banner," Air University, August 12, 2021, <https://www.airuniversity.af.edu/CASI/Display/Article/2729781/pla-likely-begins-construction-of-an-intercontinental-ballistic-missile-silo-si/>; Office of the Secretary of Defense (OSD), "Military and Security Developments Involving the People's Republic of China 2020," Annual Report to Congress, 2020, <https://media.defense.gov/2020/Sep/01/2002488689/-1/-1/1/2020-DOD-CHINA-MILITARY-POWER-REPORT-FINAL.PDF>; Rosoboronexport, "Club-K," 2021, <http://roe.ru/esp/catalog/marina-de-guerra/armas-de-la-nave/klab-k/>; Sam LaGrone, "Inside Aegis Ashore," USNI News, August 8, 2013, <https://news.usni.org/2013/08/08/inside-aegis-ashore>; and Joby Warrick, "China Is Building More Than 100 New Missile Silos in Its Western Desert, Analysts Say," *Washington Post*, June 30, 2021, https://www.washingtonpost.com/national-security/china-nuclear-missile-silos/2021/06/30/0fa8debc-d9c2-11eb-bb9e-70fda8c37057_story.html.

To simplify negotiations and reduce the need for intrusive inspections, if one ground-based launcher of a given type has been used to launch a cruise, ballistic, or boost-glide missile over a distance of greater than 475 kilometers, then all launchers of that type would be accountable—even if loaded with missiles of a shorter range or with no missile at all. Russia's 9P78 (Iskander) launchers, for example, can be deployed with the SSC-7 cruise missile (which has a range of 490 kilometers or 305 miles), the SS-26 ballistic missile (which has a range of 350 kilometers or 220 miles), and perhaps also the SSC-8 cruise missile. All such launchers would be accountable.

The proposed treaty would limit all bombers with a range greater than 2,000 kilometers—a somewhat broader array of types than are limited under New START. Specifically, medium bombers, such as Russia's Tu-22M bomber, would be accountable because improved long-range munitions could confer them with capabilities similar to heavy bombers.¹⁴⁰ Similarly, U.S. bombers that have been converted to deliver only nonnuclear munitions and are not accountable under New START would be accountable under the proposed treaty.

Given these provisions, it appears that China, Russia, and the United States currently possess roughly equal numbers of accountable launchers and accountable bombers—though there are large uncertainties in the estimates for China and particularly Russia.¹⁴¹ (See table 3 for rough estimates of the number and types of accountable systems each state currently possesses.)

Looking forward, each state's force of accountable launchers and accountable bombers is likely to grow. The United States possesses a few hundred ground-based M142 High

Mobility Artillery Rocket System (HIMARS) launchers and Multiple Launch Rocket System M270A1 launchers that would not be accountable today. However, it plans to test the former type, and perhaps the latter type too, with a missile that has a range longer than 475 kilometers—at which point all launchers of each type used in any tests would become accountable. China, meanwhile, is expanding its missile and bomber forces, including through the construction of at least 230 new ICBM silos, and may keep pace with the United States. The opacity around Russia’s nonstrategic missile force makes its current composition and future trajectory difficult to assess—though it is likely that Russia currently possesses more than the 800 accountable launchers and accountable bombers listed in table 3 and is constructing more. As a result, it is possible, albeit far from certain, that the rough equality in accountable launchers and accountable bombers will persist, which would enhance the treaty’s political feasibility.

In any case, the central limit chosen should be slightly higher than any state’s arsenal of accountable launchers and accountable bombers at the time of entry into force. This approach, which mirrors the idea behind the SALT I Interim Agreement, would forestall the nascent missile arms race. Moreover, by allowing states to partially implement their modernization plans, perhaps without having to dismantle existing weapons, it would be more politically palatable than a treaty that required reductions. The trade-offs imposed by the limit would enhance security. If China, for example, sought to expand its strategic forces significantly, it would have to reduce its regional forces, mitigating U.S. concerns about the military balance in the Western Pacific. Meanwhile, if the United States decided to build up its regional forces significantly, it would have to reduce its strategic forces, mitigating Chinese concerns about the survivability of its nuclear arsenal.

CENTRAL LIMITS FOR ACCOUNTABLE LAUNCHERS AND ACCOUNTABLE BOMBERS

The treaty should limit China, Russia, and the United States to an equal number of accountable launchers and accountable bombers. The limit chosen should allow each state to make modest increases in such launchers and bombers after the treaty’s entry into force.

The treaty should exempt from accountability any launchers for SLBMs that were converted into launchers for SLCMs prior to entry into force.

Each accountable launcher or accountable bomber should first become accountable at the following stage of development:

- For fixed launchers, when silo doors are attached to a missile silo or when a missile is deployed within a silo, whichever happens earlier
- For mobile launchers, when a launcher leaves the production facility for the first time

- For SLBM launchers, when an SSBN puts to sea for the first time
- For accountable bombers, when a bomber takes flight for the first time

In implementing the treaty provisions, the following definitions should apply:

- “Accountable bomber” means a bomber of a type, any one of which has an unrefueled range—when carrying an ordnance load of at least 5,000 kilograms (11,000 pounds)—in excess of 2,000 kilometers.¹⁴²
- “Accountable launcher” means an accountable ground-based launcher or an SLBM launcher.
- “Accountable ground-based launcher” means a ground-based device of a type, any one of which has been used to launch a cruise, ballistic, or boost-glide missile with a range in excess of 475 kilometers against a ground-based target.
- “SLBM launcher” means a device on a ship or submarine of a type, any one of which has been used to launch a ballistic missile with a range in excess of 600 kilometers (370 miles) against a ground-based target.
- “Ballistic missile” means a weapon-delivery vehicle that has a ballistic trajectory over most of its flight path.
- “Boost-glide missile” means a weapon-delivery vehicle that sustains unpowered flight through the use of aerodynamic lift over most of its flight path. A reaction control system designed to change a vehicle’s attitude is not considered capable of powering flight.
- “Cruise missile” means an unmanned, self-propelled weapon-delivery vehicle that sustains flight through the use of aerodynamic lift over most of its flight path.

The parties should agree that, for the purposes of treaty implementation, the definition of an accountable launcher includes any ground-based launcher of a type derived from a ship-based vertical launch system from which a cruise missile with a range in excess of 475 kilometers has been launched against a ground-based target.

The definitions for an accountable launcher or accountable bomber are not intended to include systems used to launch target missiles for missile defense tests, provided such systems are of a different type and distinguishable from any accountable launcher or accountable bomber.

Definitions of missile ranges are discussed in appendix A.

Verification

The verification and monitoring regime should consist of two main parts: information exchanges and confirmation through NTM and on-site inspections.

Data exchanges. China, Russia, and the United States should exchange baseline information, comprehensive semiannual updates, and regular notifications about accountable launchers and accountable bombers. This exchange would enable each party to maintain an identical database that it would attempt to verify. A party would be required to declare and provide notifications about all its accountable launchers and accountable bombers, regardless of whether they were based on its own territory.

VERIFICATION: DATA EXCHANGES AND NOTIFICATIONS

As part of the baseline data exchange thirty days after the treaty's entry into force, each party should:

- List all its types of accountable launchers and accountable bombers
- Declare how many accountable launchers and accountable bombers it possesses, in aggregate and disaggregated by type
- Identify externally observable distinguishing features (should any exist) to differentiate accountable launchers and accountable bombers from similar nonaccountable systems (should any exist)
- Identify all bases for accountable launchers and accountable bombers
- Declare, for every base for mobile accountable ground-based launchers, each fixed structure and unenclosed storage area (whether or not it typically contains accountable launchers)
- Provide a unique identifier (UID) for every mobile accountable ground-based launcher and assign each such launcher to the base on which, and the specific fixed structure or unenclosed storage area in which, it is typically stored (where possible, the parties may utilize preexisting UIDs assigned pursuant to New START or any future arms control treaty)
- Provide a site diagram for each base for accountable ground-based launchers, showing—with geographic coordinates—the location of each fixed launcher, each fixed structure (whether or not it typically contains accountable launchers), and the boundaries of each unenclosed storage area (whether or not it typically contains accountable launchers)

The parties should plan an implementation meeting to discuss any questions arising from the baseline data exchanges.

Following the baseline data exchange, the parties should exchange the same categories of data every six months.

The parties should notify each other of the production, first deployment, or dismantlement of accountable launchers and accountable bombers. Deployment notifications for fixed accountable ground-based launchers should specify the coordinates of the deployment location. Deployment notifications for mobile accountable ground-based launchers should specify the base on which, and the fixed structure or unenclosed storage area in which, the launcher is typically stored.

The parties should also notify one another of any change to the fixed structure or unenclosed storage area in which a mobile accountable ground-based launcher is typically stored. Such a notification should specify the new fixed structure or unenclosed storage area in which (and, if necessary, the new base on which) the missile is typically stored.

In implementing the provisions of this treaty, the following definitions should apply:

- “Base” means a facility at which accountable launchers or accountable bombers are typically stored and maintained. A facility designed, intended, or used to accommodate accountable launchers or accountable bombers temporarily is not considered to be a base, provided that no accountable launchers or accountable bombers are typically stored or maintained there.
- “Fixed structure” means a unique structure within a base designed, intended, or used to store mobile accountable ground-based launchers.
- “Unenclosed storage area” means any area, other than a fixed structure, designed, intended, or used to store mobile accountable ground-based launchers.

National technical means. The parties should be able to use NTM, including satellite imagery, to verify numbers of accountable bombers, fixed accountable ground-based launchers (silos), and SLBM launchers. Because of developments in satellite technology, the NTM capabilities of China, Russia, and the United States have improved dramatically since the 1970s. Even back then, the SALT I Interim Agreement and SALT II Treaty, which limited similar categories of arms, did not include on-site inspections because those arms were large enough to be visible with overhead imagery. The parties should agree, however, not to interfere with one another’s NTM.

VERIFICATION: NON-INTERFERENCE WITH NTM

Each party should agree not to interfere with the NTM of other parties by, for example, using concealment measures to impede the verification of accountable launchers or accountable bombers located on bases. This treaty provision is not intended to require any party to modify any existing facility.

On-site inspections. Although on-site inspections of fixed launchers would be unnecessary, on-site inspections to verify mobile accountable ground-based launchers would be needed. Although they can be stored in unenclosed areas, such launchers are usually based and maintained inside structures (garages) when they are not deployed in the field, limiting the utility of overhead imagery.¹⁴³

The United States already inspects Russia's mobile ICBM launchers under New START. Inspections under the proposed treaty here would be similar but less intrusive in one important respect. Inspectors would aim to confirm the assignment of mobile accountable ground-based launchers to a specific fixed structure or unenclosed storage area as well as their absence from fixed structures and unenclosed storage areas declared to not contain them. However, there would be no requirement, as in New START, to display missile front sections, revealing the attached reentry vehicles and other sensitive objects.

Inspectors would have the right to verify all the mobile accountable ground-based launchers in a given fixed structure or unenclosed storage area—typically at least two and sometimes more. By contrast, under New START, inspectors can verify just one launcher on each inspection. For this reason, the proposed treaty provides for fewer inspections than New START. Specifically, each party would be entitled to conduct ten inspections annually against each of the other parties, whereas New START permits eighteen inspections annually against the other party. Inspections could take place on the territory of a third party if mobile accountable ground-based launchers are based there. For example, HIMARS launchers, which would likely have become accountable by the time the proposed treaty entered into force, are currently based with U.S. Army and Marine units on allied territory.¹⁴⁴

VERIFICATION: INSPECTIONS OF MOBILE ACCOUNTABLE GROUND-BASED LAUNCHERS

To verify declared information, each party should be permitted to conduct up to ten inspections per year at bases for mobile accountable ground-based launchers of each other party.

The inspecting party should inform the host state of a pending inspection at least twenty-four hours in advance of the inspection team's arrival in country.

No later than one hour after an inspection team arrives in country and designates for inspection a base for mobile accountable ground-based launchers, the inspected party should cease any movements of such launchers into or out of the base.

Prior to departing for the designated base, the host state escort team should inform the inspection team if 50 percent or more of the mobile accountable ground-based launchers declared to be typically stored at the base are temporarily absent.¹⁴⁵ If so, the inspection team should have the right to (1) proceed with the inspection as planned,

(2) designate for inspection a different base for mobile accountable ground-based launchers, or (3) decline to conduct an inspection with no reduction in the number of inspections the inspecting party is entitled to conduct.

After arrival at the designated base, the escort team should inform the inspection team of (1) the total number of mobile accountable ground-based launchers located at the base; (2) for each fixed structure or unenclosed storage area in which mobile accountable ground-based launchers are located, the number of such launchers present and their UIDs; and (3) a list of any fixed structures or unenclosed storage areas in which no mobile accountable ground-based missiles are located.

During an inspection, the inspection team should have the right to designate and inspect one fixed structure or unenclosed storage area declared to contain mobile accountable ground-based launchers for the purposes of confirming the total number of such launchers in that fixed structure or unenclosed storage area and their UIDs. Additionally, if applicable, the inspection team should have the right to designate and inspect one fixed structure or unenclosed storage area declared not to contain mobile accountable ground-based launchers to confirm the absence of such launchers.

Within thirty days of the first deployment of a new type of mobile accountable ground-based launcher, one launcher of this type must be exhibited to inspectors to enable them to establish the launcher's physical dimensions and to take photographs to facilitate future verification. If this exhibition is not possible during a routine inspection, then it should not count against the inspecting party's inspection quota.

Eliminations. Parties would be permitted to eliminate accountable launchers and accountable bombers as necessary to meet the treaty's numerical limits by following specified procedures—the results of which could be confirmed through NTM.

VERIFICATION: ELIMINATION PROCEDURES

Any party that plans to eliminate accountable launchers or accountable bombers must notify the other parties thirty days in advance of the elimination process, detailing the type and number of accountable launchers or accountable bombers to be eliminated and the planned location for the elimination procedures. For fixed accountable ground-based launchers, the notification should include the launchers' deployment locations. For mobile accountable ground-based launchers, the notification should include the launchers' UIDs.

The elimination procedures should depend on the type of system being eliminated and closely follow those specified by New START, with the requirement that no SLBM launcher on an SSBN should be considered eliminated until all the SLBM launchers on that SSBN have been eliminated.¹⁴⁶

Eliminated accountable launchers and accountable bombers should remain visible to NTM for a period of sixty days after elimination procedures have been completed. After this sixty-day period has expired, eliminated accountable launchers and accountable bombers should no longer be considered accountable.

Assessment

Technical feasibility. The proposed agreement is built on Russia's and the United States' extensive experience in implementing limits on heavy bombers and various types of missile launchers pursuant to New START, START I, the INF Treaty, and the SALT I Interim Agreement. Currently, under New START, Moscow and Washington regularly exchange detailed information on ICBM launchers, SLBM launchers, and heavy bombers, and inspect all accountable systems, including the launchers for mobile ICBMs.

Trilateral arms control would represent a significant increase in complexity, but most of the additional challenges would be political. While China might operate its mobile missile forces in a crisis or conflict in a quite different way from Russia (including the extensive use of underground facilities), its day-to-day operations appear to be fairly similar.¹⁴⁷ Thus, from a purely technical perspective, the inclusion of China would represent only a modest challenge. While a trilateral treaty would likely be somewhat more difficult to negotiate, implementation would only be marginally more complex. After all, data exchanges and inspections would take place bilaterally between each pair of parties; they would not be orchestrated by an international inspectorate.

The biggest technical challenge would be verifying the absence of undeclared accountable launchers—mobile ground-based launchers, in particular. Some of these launchers are small and highly maneuverable and hence tricky to detect with NTM. A party could therefore attempt to cheat and retain more weapons than permitted by the treaty by failing to declare some of them. Nonetheless, the United States has previously assessed this problem to be manageable. In 1988, during congressional hearings about the INF Treaty, the U.S. Air Force chief of staff, General Larry Welch, testified that

to maintain a militarily useful force of covert missiles, [the Soviets] would need an elaborate hidden infrastructure to hide the missiles, periodically test them and provide an effective means of employing them in a crisis. They would run a high risk of detection over time. . . . Apart from these technical considerations, the military utility of such a cheater force would be low compared to the risk.¹⁴⁸

The NTM capabilities of all three parties are almost certainly more sophisticated today than U.S. capabilities were at the time of this hearing. Moreover, the verification challenges facing the INF Treaty were likely greater than the ones facing the proposed treaty here. The

INF Treaty sought to eliminate an entire class of weapons; the proposed agreement would limit each party to somewhere in excess of 1,000 accountable launchers and accountable bombers. The size of a militarily significant violation—the kind of violation that a verification regime should be able to detect if a treaty is to be viable—was smaller, therefore, under the INF Treaty than it would be under the proposed agreement. (If states are seriously concerned about undeclared launchers, they could agree to use perimeter portal monitoring to track all launchers leaving production facilities. This technique, which was used in START I and the INF Treaty, involves continuous monitoring of all a production facility's exits that are large enough for a missile to pass through to ensure that no undeclared missiles are leaving the facility. In practice, however, all parties would likely agree that this approach would be unacceptably intrusive.)

Political feasibility. The emerging arms race in ground-launched missiles and somewhat less competitive but still significant developments in aircraft technology appear to disquiet Beijing, Moscow, and Washington. Both parties in the U.S.-Russian and U.S.-Chinese dyads express concerns about the other's programs. Below the surface, there may also be some concern, particularly in Moscow, about the possibility of renewed competition between China and Russia over the long term. Moreover, and perhaps most importantly, technological developments are driving up the risk of escalation should growing tensions spark a conventional conflict.

The treaty proposed here could help restrain an adversary's threatening capabilities, mitigate the costs and tensions associated with arms racing, and manage the escalation risks created by growing nonnuclear threats to nuclear forces. While the first two of these advantages, in particular, may be understood by Beijing, Moscow, and Washington, crafting a treaty that each participant viewed as beneficial to its specific interests would likely be more difficult when there are three parties rather than two. These difficulties would be magnified by the poor state of U.S.-Russian and U.S.-Chinese relations.

One threshold question is whether each party could accept the basic compromise underlying the proposed treaty: the United States' Aegis Ashore launchers would be accountable; sea-based missiles, other than SLBMs, would not. (As argued in chapter 1, greater transparency about SLCMs and SLBGMs would be both possible and desirable and could enhance the viability of the proposed agreement.)

In evaluating this trade-off, the United States should recall that it has always justified its Aegis Ashore deployments on the need to combat Iranian missiles and that this agreement would not stop it from retaining, or even modestly expanding, such capabilities. Meanwhile, China and Russia should note that, although they lag the United States in sea-based missiles, they have made considerable efforts to enhance their capabilities in this area. Indeed, limits on SLCMs (and air-launched cruise missiles, for that matter) are noticeably absent from Putin's proposal for a verified moratorium on Russian and U.S. deployments

in Europe (including European Russia) of any missiles that were formerly prohibited under the INF Treaty.¹⁴⁹ This proposal hints that Russia may entertain limits and transparency on land-based missiles by themselves (though the treaty proposed here would, by limiting bombers, also limit air-launched missiles indirectly).

Another challenge in securing a treaty is Beijing's relative lack of experience with arms control, particularly negotiating and implementing limits on missiles or aircraft. Specifically, inspections of mobile ground-based launchers would represent a radical increase in transparency for China and hence could be a potential deal breaker. Two characteristics of the proposed agreement, however, should make it somewhat more palatable to Beijing than, say, limits on missiles or warheads. First, the parties would use NTM to verify silo launchers, SLBM launchers, and accountable bombers. Second, the intrusiveness of inspections, which would be limited to mobile ground-based launchers, would be mitigated since inspectors would not need access to missile front sections, as in New START. Indeed, China would not be required to provide any information at all about its warheads.

If China concluded that this basic treaty concept would advance its interests but that it could not accept on-site inspections, the parties should, at least initially, consider a non-legally binding agreement and rely exclusively on NTM for verification for some period of time. While this approach would present significant challenges—in trying to verify mobile launchers, in particular—the corresponding benefit of engaging China in a mutually beneficial arms control agreement would be considerable. If this arrangement proved successful, the parties could then enshrine the limits in a treaty with full verification provisions.

An additional consideration for China is that it appears to target states besides the United States and perhaps Russia with its missile forces. Various DF-21 battalions in central and southern China, for example, appear to hold Indian targets at risk.¹⁵⁰ China may therefore view the proposal's failure to constrain Indian forces as a significant flaw—though China's ongoing missile competition with the United States is likely a more immediate concern than its competition with India.

Finally, within the United States, opposition to the proposed treaty may come from officials and analysts who are concerned about a new missile gap—in particular, in regional missile forces vis-à-vis China. Some would probably worry that the proposed treaty would enshrine U.S. inferiority in regional missiles and would likely argue that the United States should build up its force before seeking limits through arms control.

One problem with this approach is that deploying mobile ground-launched missiles to allied territory, where they would be militarily useful, would likely prove politically fraught. Local populations would almost certainly oppose such deployments, even for missiles that were not nuclear-armed. As a result, the deployments would likely be quite small—if, that is, they could be agreed on at all. The treaty proposed here would therefore foreclose an

option—a major buildup of forward-deployed mobile ground-launched missiles—that, in practice, the United States would likely not be able to execute anyway. (Instead, the United States would probably rely on SLCMs and perhaps SLBGMs, which would not be limited by the proposed treaty, to meet its deterrence requirements.)

A second problem is the costs and risks of a buildup. Even more important than the direct financial costs is the risk of escalation created by apparently unlimited deployments that lead China and Russia to fear that, in a conflict, the United States might attack their leadership, nuclear forces, and nuclear C3I systems. There are psychological, bureaucratic, and political reasons why this danger tends to get ignored but no good reason why it should be.¹⁵¹

The costs of building up forces before pursuing arms control would increase further if it stimulated arms racing. Further arms buildups may be unavoidable in any case since an arms control agreement would take time to negotiate, even if all three parties were willing to negotiate in good faith. And this near inevitable buildup might actually facilitate an arms control process by allowing states to feel that they have met their deterrence requirements. However, given China's rapidly growing economy and Russia's likely ability to further redirect domestic spending to the military, there is a clear risk of serious arms racing here.

Against this background, arms control could complement deterrence by reducing the risks—escalation and arms racing—associated with arms buildups. For arms control to have any chance of success, treaties must ultimately be fair; any proposal that enshrined superiority for the United States in regional *and* strategic forces would be summarily rejected by both Beijing and Moscow. The proposal outlined here recognizes the rough equality in accountable launchers and accountable bombers that already exists between China, Russia, and the United States—and that may continue for at least some time into the future. The question that decisionmakers in Washington—and Beijing and Moscow, for that matter—must ask themselves is how the risks of trying to break away from this rough equality compare to the risks of living with it.

THE HOLY (AMERICAN) GRAIL: A U.S.-RUSSIAN WARHEAD- LIMITATION TREATY

NEW START limits the 2,700 or so nuclear warheads deployed on ICBMs and SLBMs—less than 25 percent of Russia and the United States’ combined total inventory of warheads. It also limits the number of heavy bombers, but they are treated as though each carries a single warhead even though they could carry many more. No other warheads—those in storage, those being transported, and those that have been retired and are awaiting dismantlement—are even indirectly accountable. (Table 4 provides an estimate of the Russian and U.S. inventories.)

New START’s traditional design focuses on limiting (most) long-range delivery vehicles and their launchers. In the process, it is both possible and desirable to limit the number of warheads that are physically deployed on (most of) those delivery systems. However, the complexities of extending arms control to any other warheads—even the warheads for heavy bombers that are stored on bases already subject to inspection—have so far prevented it.

Limiting strategic delivery vehicles and launchers has provided—and continues to provide—considerable value. New START and its predecessors have helped to cap and reverse the arms race and to mitigate the uniquely serious escalation risks created by the threats that Russia’s and the United States’ strategic nuclear forces pose to one another. By contrast, with the primary exception of the now-defunct INF Treaty, nonstrategic delivery systems have been left out of arms control. The often-unarticulated justification (correct or not) has been that because these systems generally carry lower-yield warheads and are

TABLE 4

ESTIMATED WARHEAD INVENTORIES FOR RUSSIA AND THE UNITED STATES

| Warhead Type | Russia | United States |
|---|--------------------|--------------------|
| Operational | -4,500 | 3,750 ^a |
| Deployed on intercontinental ballistic missiles and sea-launched ballistic missiles | 1,410 ^b | 1,340 ^b |
| Warheads for heavy bombers stored at heavy bomber bases | ~200 | ~300 |
| Other operational warheads | ~2,900 | ~2,100 |
| Awaiting Dismantlement | -1,800 | -2,000 |
| Total | -6,300 | -5,750 |

Note: These figures pertain to actual warheads and do *not* count one warhead for each deployed heavy bomber (as New START does). They are inferred by the authors from the best data available as of October 21, 2021.

^a As of September 2020.

^b These figures are not known exactly but are much less uncertain than those marked ~.

Sources: U.S. Department of State, Bureau of Arms Control, Verification and Compliance, “Transparency in the U.S. Nuclear Weapons Stockpile,” fact sheet, October 5, 2021, <https://www.state.gov/transparency-in-the-u-s-nuclear-weapons-stockpile/>; U.S. Department of State, Bureau of Arms Control, Verification and Compliance, “New START Treaty Aggregate Numbers of Strategic Offensive Arms,” fact sheet, September 28, 2021, <https://www.state.gov/new-start-treaty-aggregate-numbers-of-strategic-offensive-arms/>; U.S. Department of State, Bureau of Arms Control, Verification and Compliance, “New START Treaty Aggregate Numbers of Strategic Offensive Arms,” fact sheet, December 1, 2020, <https://www.state.gov/new-start-treaty-aggregate-numbers-of-strategic-offensive-arms-15/>; Hans M. Kristensen and Matt Korda, “United States Nuclear Weapons, 2021,” *Bulletin of the Atomic Scientists* 77, no. 1 (2021): 44; and Hans M. Kristensen and Matt Korda, “Russian Nuclear Weapons, 2021,” *Bulletin of the Atomic Scientists* 77, no. 2 (2021): 91.

more suited to tactical missions, such as battlefield use, the risks of further escalation following the first use of NSNWs would be lower than in the case of the first use of strategic weapons.

Nonetheless, the distinction between strategic and nonstrategic delivery systems is unsatisfactory. Any nuclear detonation would have “strategic” consequences whether the delivery vehicle involved was strategic or nonstrategic. Nominally nonstrategic delivery systems—most notably, SLCMs—have long been able to reach targets deep in an adversary’s homeland and thus threaten that state’s strategic forces and C3I systems. Meanwhile, strategic systems could be used in tactical roles. For example, U.S. Trident D5 SLBMs loaded with low-yield nuclear warheads are technically capable of being used in this way—though the

United States asserts that this capability “is not intended to enable, nor does it enable, ‘nuclear war-fighting.’”¹⁵²

These conceptual flaws have become more glaring in the decades since the Cold War ended. The U.S. Department of Defense assesses that Russia maintains “up to 2,000” nuclear warheads for nonstrategic delivery systems—compared to the estimated 230 in the U.S. arsenal—likely to compensate for its perceived conventional inferiority relative to NATO and possibly China.¹⁵³ However, the United States and its allies worry that Russia may use this force to enable conventional aggression, particularly against the Baltic states, by seizing territory and then threatening nuclear use should NATO launch a conventional response. If NATO ignored these threats and responded anyway, there is concern that Russia would engage in limited nuclear use to try to coerce NATO into backing down for fear of further escalation.

As a result, the Biden administration has reiterated the long-standing U.S. goal of “new arms control that addresses all of Russia’s nuclear weapons.”¹⁵⁴ This is easier said than done. U.S. and NATO concerns are primarily about Russia’s perceived nuclear doctrine—but doctrine cannot credibly be constrained by an agreement. The traditional arms control approach of constraining delivery systems does not seem much more promising because nonstrategic delivery systems, such as tactical aircraft, are all dual-use and neither state has any interest in limiting them.

As a result, the United States has come to focus on the warheads themselves. In the abstract, the United States would probably like to limit only nonstrategic nuclear warheads (that is, the warheads carried by nonstrategic delivery systems). However, nonstrategic warheads in storage cannot be readily distinguished from strategic warheads (those carried by strategic delivery systems)—not least because classification rules would prevent inspectors from directly viewing any warheads. Furthermore, even if discrimination were possible, the difference in size between the Russian and U.S. arsenals of nonstrategic warheads would make reaching an agreement to limit only those warheads politically infeasible. As a result, within the United States, considerable support for a treaty that would impose a single limit on all Russian and U.S. warheads, irrespective of their type or deployment status, has emerged (even if it is not entirely clear that such an agreement would actually address the United States and allies’ concerns).¹⁵⁵

Russia has previously expressed support for a limit on all warheads or at least for steps in that direction. In 1997, Moscow and Washington agreed to a framework for negotiations over START III, as part of which they committed to negotiate provisions related to the transparency and destruction of strategic warheads and to explore transparency and confidence-building measures for nonstrategic systems.¹⁵⁶ This agreement catalyzed some technical investigations, including on warhead verification, but it petered out after negotiations ended without a treaty.

More recently, Russia has expressed support for a warhead limit as a way to redress the asymmetry between the U.S. and Russian stockpiles of strategic warheads. While most Russian warheads not loaded onto ICBMs or SLBMs are nonstrategic, most U.S. warheads in that category are strategic. In the 2000s, some Russian officials and experts supported a warhead limit on the grounds that it could constrain the United States' ability to upload reserve strategic warheads onto its larger force of strategic delivery systems. In 2009, for example, Foreign Minister Sergey Lavrov indicated that Russia would seek to use upcoming negotiations over what would become New START to limit "all warheads . . . not only so called operationally deployable, but also the warheads in warehouses."¹⁵⁷ (Given the context for these remarks—an agreement to negotiate a new strategic offensive arms control agreement—it is possible that Lavrov was actually calling for limits on all strategic warheads rather than all warheads, but his concern over the United States' so-called upload potential was clear.) Somewhat to the surprise of U.S. negotiators, however, Russia did not press this issue during New START negotiations and has not flagged it much since.¹⁵⁸ In fact, recently, it is U.S. officials and experts that have begun to express concerns about Russia's upload potential.¹⁵⁹

In late 2020, Moscow and Washington publicly agreed, in principle at least, to a one-year freeze in overall warhead numbers in return for a one-year extension of New START. However, they could not finalize an agreement, largely because of disagreements over verification: Russia refused it, while the United States reportedly insisted on perimeter portal monitoring of assembly/disassembly facilities.¹⁶⁰ This impasse does not bode well for Russia's willingness to negotiate over a verified warhead-limitation treaty.

Even so, given the support that such a treaty attracts in the United States, the concept is analyzed in detail here. Ultimately, even if both sides supported it, verification challenges would likely preclude agreement today. We, therefore, do not try to sketch out a detailed verification protocol, but instead identify critical challenges and a research agenda, comprising unilateral and joint efforts, to solve them. If Russia ever decides to support a warhead limit again, these steps should leave the two states well placed to begin treaty negotiations. But, even if Russia does not, many of the steps would still be useful risk-reduction measures in their own right.

Solution Concept

A warhead limit should apply to all Russian and U.S. warheads regardless of their type, location, or deployment status. A more difficult issue is whether it should also apply to the Russian and U.S. warheads awaiting dismantlement, of which there are currently thousands. Many U.S. experts argue it should not. However, warheads awaiting dismantlement are indistinguishable from operational warheads in storage and are not even stored separately.¹⁶¹ Moreover, by the time a warhead limit could realistically be negotiated, both states would likely have far fewer warheads awaiting dismantlement, making it more feasible to count them under the treaty's central limit.

One potential complication here is the somewhat different maintenance cycles for Russian and U.S. warheads. Russian warheads have shorter service lives than their U.S. counterparts and must be remanufactured regularly. A 2001 study, for example, estimated that Russian pits (the fissile cores of nuclear weapons) were viable for only seven to fifteen years.¹⁶² By contrast, some U.S. warheads were manufactured more than forty years ago.¹⁶³ Russian warhead service lives have likely increased in the last two decades. Nonetheless, going forward, Russia's queue of warheads awaiting dismantlement will likely become longer than the United States' queue. This asymmetry is a potential problem because a treaty that limited the two sides to parity in total inventories would force Russia to retain a smaller operational stockpile, which it could regard as unfair (while the United States would regard unequal limits on total inventories as similarly unfair). However, this issue may not become a significant political challenge if Russia's dismantlement queue does not become too much bigger than the United States' queue.¹⁶⁴

A treaty would also be more feasible if it did not require Russia or the United States to make major changes to their force structures. The numerical ceiling should therefore require only modest reductions in the U.S. and Russian warhead inventories (as they are constituted at the time of entry into force). This relatively conservative approach is also appropriate given the magnitude of the implementation challenges. Specifically, the size of a militarily significant violation comes down with the warhead limit. Avoiding an overly ambitious target for reductions would therefore reduce the load carried by a largely novel verification regime. If treaty implementation were successful, a successor agreement requiring deeper warhead reductions (along with potentially more intrusive verification measures) could subsequently be negotiated.

As with all arms control agreements, the parties should be given some time to make the required reductions: five years seems appropriate for a treaty that should remain in force for, say, fifteen years. To avoid the accusations of bad faith that occurred early in New START's implementation, the parties should agree not to increase the net size of their warhead inventories in the meantime.

CENTRAL LIMITS IN A U.S.-RUSSIAN WARHEAD-LIMITATION TREATY

Russia and the United States should agree that each party will reduce and limit its nuclear warheads. The numerical limit chosen should require that each state make modest reductions in its nuclear warheads following the treaty's entry into force. This limit should apply to all the parties' warheads, irrespective of their type, location, deployment status, and whether or not they are awaiting dismantlement.

Each party should further commit to reduce its nuclear warheads to meet the treaty's central limit within five years of entry into force and, in the meantime, to not increase

its nuclear warheads above the number it possessed at the time of entry into force. The treaty should remain in force for fifteen years.

For the purposes of treaty implementation, a nuclear warhead should become accountable when fissile material and conventional high explosives or any other energetic material are first assembled within a single device. A nuclear warhead should cease to become accountable as soon as fissile material and conventional high explosives or any other energetic material are no longer assembled within a single device.

Verification

Verifying a warhead limit would involve data exchanges, notifications, and on-site inspections, supplemented by each state's NTM capabilities. These measures build directly on New START's verification provisions and assume that New START or a successor treaty with similar provisions will remain in force.

Conceptually, warheads can be divided into four categories, depending on how inspections could be most easily facilitated (and, indeed, whether they would be possible at all).

1. **Warheads deployed on ICBMs, SLBMs, and heavy bombers.** Under New START, inspectors are already permitted to count the warheads (or, more specifically, the shrouded reentry vehicles) emplaced on deployed ICBMs and SLBMs. Additionally, New START permits inspectors to count any nuclear armaments located on heavy bombers—though, as a matter of policy, neither Russia nor the United States load nuclear weapons onto aircraft in peacetime.¹⁶⁵
2. **Nondeployed warheads stored at ICBM, SLBM, or heavy bomber bases.** Inspectors already visit these bases pursuant to New START but have no rights to inspect warheads in storage. Nonetheless, it would be sensible to allow verification of those warheads during inspections pursuant to New START or a successor agreement.
3. **Other warheads in storage.** Neither Russia nor the United States keeps nonstrategic warheads mated with delivery systems in peacetime. Most, if not all, of these warheads, as well as many reserve strategic warheads and warheads awaiting dismantlement, are stored on bases that are not subject to New START inspections. As a result, a dedicated inspection regime would be needed to verify them. (In a crisis or conflict, some of these warheads could be loaded onto delivery systems, but if that were to occur, treaty implementation would inevitably be suspended.)
4. **Warheads in transport.** Warheads are regularly transported, including after assembly and before disassembly. Warheads in transit could not realistically be subject

to inspections; rather, the goal would be to use inspections of storage facilities and deployed delivery systems to verify that the consequences of warhead transport operations were consistent with the declarations about those operations.

Data exchanges and notifications. The first step in verification would be a comprehensive warhead data exchange shortly after the treaty's entry into force (the baseline exchange) and then once every 180 days thereafter. In between comprehensive exchanges, each party would be required to notify the other of any changes to this data and also of any warheads that have been assembled or disassembled. Given the particular security sensitivities around warheads, such notifications should be provided in batches: one exchange every ten days, not more or less continuously as under New START. In addition, each state should be required to provide notifications to the other (1) before the transport of warheads between declared sites, (2) after the transport has arrived at its destination, and (3) after all the warheads in the transport have been unloaded. For security reasons, the notification prior to a transport need only specify a ten-day window in which the transport is expected to depart. (Warheads can also be transported within a site. Although such transports would not need to be declared specifically, the parties would be required to declare the resulting changes to the baseline data.)

VERIFICATION: DATA EXCHANGES AND NOTIFICATIONS

Within ninety days of the treaty's entry into force, each party should provide the other with the following baseline information (correct as of noon on the first full day after entry into force):

1. Its total number of warheads
2. The number of those warheads in transport between sites
3. A list of all sites on which its nuclear warheads are located; the number of warheads at each site deployed on ICBMs, SLBMs, or heavy bombers; and the number of warheads at each site not deployed on ICBMs, SLBMs, or heavy bombers
4. For each such site, a site diagram, conveying inspection boundaries and the locations of any fixed structures wholly or partially within the inspection boundaries
5. For each such fixed structure, a diagram of its interior, showing all rooms and interior and exterior access points within the inspection boundaries
6. For each such room, the number of warheads stored within the room; and a list showing the type and UID of, and the number of warheads within, each warhead storage container in that room
7. For each type of warhead storage container present at any site, its physical dimensions, the maximum number of warheads that it can accommodate, and a photograph

For ICBM, SLBM, and heavy bomber bases, the inspection boundaries should be identical to those declared under New START or any successor treaty, except that they should also include the whole of each fixed structure.

For other sites at which nuclear warheads are present, the inspection boundaries should include the whole of each fixed structure, except that for fixed structures in which warheads are assembled and disassembled, the inspection boundaries should include only those rooms that currently store, are designed to store, or have stored complete nuclear warheads and in which assembly or disassembly does not occur.

Starting 100 days after entry into force and every ten days thereafter, the parties should notify one another of any changes to categories 1, 2, 3, and 6 of the baseline information that occurred during a reporting period that began at noon eleven days earlier and ended at noon one day earlier (except that the first such exchange should cover the period that began at noon on the first full day after entry into force and ended at noon one day earlier). As part of these exchanges, the parties should provide notifications detailing:

- The total number of warheads that were assembled in the relevant reporting period and the UIDs of the warhead storage containers for those warheads
- The total number of warheads that were disassembled in the relevant reporting period and the UIDs of the warhead storage containers for those warheads
- The number of warheads that were removed from warhead storage containers and placed onto ICBMs, SLBMs, or heavy bombers and the UIDs of the relevant warhead storage containers
- The number of warheads that were removed from ICBMs, SLBMs, or heavy bombers and placed inside warhead storage containers and the UIDs of the relevant warhead storage containers
- The number of warheads that were moved from one warhead storage container to another and the UIDs of both the new and old containers

Starting 180 days after the treaty's entry into force and once every 180 days thereafter, each party should provide the other with updated comprehensive data for categories 1, 2, 3, and 6 of the baseline information (current as of noon one day earlier).

The parties should also be required to provide the following notifications concerning the transport of warheads between declared sites:

- A notification of an upcoming transport that specifies (1) the origin site for the transport, (2) the destination site for the transport, (3) the number of warheads in the transport, (4) the UIDs of the warhead storage containers and the number of warheads within each container, and (5) the first and last day of a window lasting no more than ten days in which the transport is expected to depart.¹⁶⁶ This notification must be provided at least one day prior to the first day of the departure window. If the transport does not occur within the ten-day window, the state

must provide a cancellation notification within twenty-four hours of the end of the window.

- A notification that the transport has arrived at the destination site within twenty-four hours of arrival.
- A notification that all warheads in the transport have been unloaded within twenty-four hours of unloading.

In implementing these provisions, the following definitions would apply:

- “Fixed structure” means a unique structure that is used to store nuclear warheads, has been used to store nuclear warheads, or is designed to store nuclear warheads.
- “Room” means an interior subdivision within or underneath a fixed structure that has an access point that is large enough for a warhead storage container to pass through. (The procedure to determine whether an access point is large enough for a warhead storage container to pass through is detailed in chapter 2.)
- “Noon” means 12:00 in the afternoon in the capital city of the state submitting a declaration or notification.

The inspection boundaries, which demarcate the area to which inspectors have access, are a potential source of controversy here. Under New START, the host state unilaterally imposes those boundaries. This process is uncontroversial because ICBMs, SLBMs, and heavy bombers are large and it would be clear if the host state had drawn the inspection boundaries to exclude, say, some ICBM silos. By contrast, warheads are much smaller and could be located outside of declared storage facilities—creating real potential for disagreement about whether the rules for drawing inspection boundaries had been faithfully followed. A first step toward solving this problem could be to negotiate inspections of empty warhead storage facilities (see chapter 2) as a way of gaining shared understanding about the challenges associated with drawing inspection boundaries and identifying possible solutions.

On-site inspections. Russia and the United States would attempt to verify this data through both on-site inspections and NTM. Inspections, however, would face a fundamental difficulty: the classification rules surrounding warheads would prevent inspectors from viewing them directly (in fact, even reentry vehicles are shrouded during New START inspections). These rules would also prevent inspectors from conducting any measurements that could reveal sensitive design information, which includes, in the case of the United States, “total weights; quantities of contained materials, including but not restricted to tritium, highly enriched uranium, and plutonium; and dimensions, configurations, and weights of fabricated components.”¹⁶⁷ Russian rules appear to be similar.

Verifying a warhead-limitation treaty would be easier if these rules were loosened (a notable precedent is the Soviet Union's permitting independent experts to measure radioactive emissions from a SLCM warhead in 1989—an experiment that would be unthinkable today).¹⁶⁸ For this reason, Moscow and Washington should individually assess whether the benefits for warhead verification of revealing additional information to one another would outweigh the security risks of doing so. Nonetheless, the treaty proposed here assumes that neither Russia nor the United States would be willing to change their classification rules.

Because of these rules, verification would largely focus on warhead storage containers on the assumption that, to prevent nuclear accidents, Russian and U.S. warheads are always kept in such containers when not attached to strategic delivery vehicles. Against this background, it is useful to first outline what the inspections would entail and then analyze the challenges created by inspectors' inability to view warheads directly.

A treaty would not need to contain any specific verification provisions for warheads deployed on ICBMs, SLBMs, or heavy bombers, which are accountable under New START and should be under a successor. However, the agreement would provide for inspections of warhead storage facilities. It should permit those facilities on ICBM, SLBM, or heavy bomber bases to be inspected during the inspections pursuant to New START or a successor and provide for dedicated inspections at other such facilities.

To inspect a storage facility, the inspection team would arrive in the host country at short notice and *then* designate an inspection site. Almost immediately thereafter, the host state would be required to restrict operations at the designated site to prevent it from hiding evidence of any noncompliance. The design of these restrictions could be controversial. In particular, given the portability of warheads, restrictions on vehicle movements on and out of the base would be helpful but also disruptive (they would prevent security patrols around the site's perimeter, for example).¹⁶⁹

Prior to the start of an inspection, the host state would provide the inspection team with any updated information (since the most recent data exchange) on the location and number of warheads at the site (categories 3 and 6 of the baseline information). The state could also shroud any sensitive objects, other than warhead storage containers, within the inspection boundaries to protect classified information unrelated to treaty implementation.

During an inspection, inspectors would be permitted to count, and read the UIDs of, all storage containers in an agreed number of rooms (this number would need to be calculated using classified information about the design of such facilities to ensure that inspections could produce the requisite level of confidence in the host state's compliance).¹⁷⁰ Inspectors would also verify the number of warheads in any types of containers that could store more than one (see below) as well as the absence of nuclear warheads in shrouded objects and storage containers declared not to contain them (see chapter 2).

Additionally, inspectors should be permitted to visit some number of rooms declared not to contain warheads to verify their absence (many of the procedures set out in chapter 2 would again be useful here). A problem could arise, however, if there were any such rooms that were considered too sensitive to be inspected. Security control centers are one possible example—though Russia has permitted U.S. personnel to visit these areas before to verify the installation of security equipment funded by the United States.¹⁷¹

Russia and the United States should agree to exempt from inspection all warheads in transport (including warheads inside transport vehicles located on declared sites). Instead, they would focus on verifying that the number of warheads and UIDs of storage containers at declared sites after a transport are consistent with the declared details of that transport. They should also agree that the small number of warheads likely undergoing maintenance at declared storage sites should not be subject to inspections.

Inspections would face a fundamental difficulty: the classification rules surrounding warheads would prevent inspectors from viewing them directly.

Inspections would be required, however, at assembly/disassembly facilities. Both Russia and the United States periodically disassemble old nuclear warheads and assemble new ones; Russia probably does so at a significantly higher rate. Therefore, even if an agreement did not require overall reductions in warhead numbers, the parties would still need to be able to remove warheads from accountancy upon dismantlement and introduce new ones after assembly. Verifying such processes—removal in particular—would be challenging.

Warhead verification. In many circumstances, inspectors' inability to view warheads would not impede effective verification. During a New START inspection of an ICBM or SLBM base, for example, inspectors are permitted to select one deployed delivery vehicle and count the emplaced reentry vehicles, after they have been shrouded, to verify the number declared by the host state. Importantly, the host state would gain no advantage by claiming that an empty reentry vehicle was a warhead. Moreover, it is also physically impossible to place more than one warhead inside a modern reentry vehicle. In consequence, New START inspectors do not need to verify that an object declared to be a warhead is actually a warhead; they simply *assume* that each reentry vehicle contains one warhead.

For similar reasons, in verifying a warhead limit, inspectors could generally also assume that there was a warhead in any storage container that was declared to contain one. Two important exceptions would arise, however.

First, at least one type of storage container that can hold multiple warheads appears to be in use. Specifically, under the Cooperative Threat Reduction program, Russia was supplied with so-called super containers that can accommodate more than one standard container.¹⁷² These super containers were intended to be used primarily for transport, when warheads

would not be inspectable, but would inevitably be used at declared sites at other times (including just before and just after transport). If these super containers are still in use—as seems likely—or if any other Russian or U.S. container types can hold more than one warhead, then it would become necessary for inspectors to verify the number of warheads inside them. After all, in this case, a state could gain an advantage by understating this number.

This problem seems manageable. Inspectors should be permitted to request the opening of some number of containers declared to contain more than one warhead to count the number of standard warhead storage containers inside. Although implementing this process might not be entirely straightforward—for example, the lids of the super containers appear to be so large that they probably require a crane to open—there do not appear to be any showstoppers.¹⁷³

Warhead dismantlement would present a second set of much greater challenges. A party could gain an advantage by falsely declaring that empty storage containers contained warheads awaiting dismantlement (by subsequently “dismantling” those nonexistent warheads, the state could retain more warheads than it had declared). As a result, it would be necessary to verify that an object declared to be a warhead awaiting dismantlement really was an actual warhead. This process would be challenging for two reasons: first, it would be necessary to define what a warhead is in terms of measurable criteria, and second, the unauthorized disclosure of classified information during the measurement process would need to be prevented.

This process is entirely different from verifying that an object declared to be nonnuclear is, in fact, nonnuclear—a verification challenge that arises in New START, for example, because nonnuclear penetration aids (designed to help an incoming missile to defeat missile defenses) may be located on ICBMs and SLBMs alongside reentry vehicles. In this case, inspectors are permitted to test objects declared to be nonnuclear with radiation detection equipment. Because these objects are not radioactive, a null result is expected and there is no danger of classified information being released (unless the inspected party is cheating). By contrast, performing a similar measurement on an actual warhead would likely reveal classified information.

Conceptual solutions to the challenge of warhead verification have been developed.¹⁷⁴ Warheads can be defined in terms of their attributes (such as the presence of a minimum quantity of fissile material and the material’s isotopic composition) or their similarity to a template (that is, an object that both sides accept is a real warhead of a given type). To avoid the unauthorized disclosure of classified information, a so-called information barrier would sit between the detection equipment and the inspector to provide an approved output—perhaps just a red light or a green light. Moreover, various approaches have been implemented and tested through both computer modeling and experiments.

This technology, however, is far from ripe for use in treaty verification. Russia and the United States must do more than simply choose hardware, though that could prove difficult enough. They would have to agree on the choice of attributes (which need not be the same for every warhead type) or how to select templates (which would have to vary between warhead types). They would also have to gain confidence that detection systems could not be compromised by the host in an effort to enable cheating (that is, by giving a green light to a fake warhead)—a particular challenge if software is used to convert the outputs of detectors into an unclassified result.

To be sure, government and independent researchers have tackled these questions from a technical perspective. But, for two reasons, the politics here cannot be ignored: the answers depend on how much confidence each state wants from the verification process, and more importantly, those answers only become solutions when both states agree on them. Today, in the absence of sustained joint research, it seems unlikely that Russia and the United States would have the shared understanding necessary to reach those solutions. Realistically, the prerequisite to negotiating warhead verification provisions in a treaty is reinvigorated joint research followed by the joint development, testing, and perhaps even manufacture of detection systems—a degree of cooperation that would not be feasible under current political circumstances.

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The Trump administration tried to bypass these challenges in its proposal for perimeter portal monitoring around assembly/disassembly facilities. However, this concept almost certainly reflected what the administration was prepared to accept politically, not the results of a detailed technical assessment. The concept was clearly inspired by the INF Treaty, which provided for perimeter portal monitoring of certain missile production facilities to verify that they were not producing missiles of a prohibited type.¹⁷⁵ However, missiles and warheads are different—in terms of their size, the sensitivity surrounding their exact shape, and the way they are packaged for transport. It seems unlikely that the X-ray scanners that the United States used for INF Treaty verification could provide much confidence that real warheads were being brought into assembly/disassembly facilities without also compromising sensitive design information. Indeed, information barrier technology would almost certainly still be needed as part of a perimeter portal monitoring system for warheads, raising all the same challenges discussed above and adding one more: while warheads are in transit, they are shielded by both their storage containers and heavily armored transport vehicles—severely complicating the verification process.¹⁷⁶ Of course, some fraction of the warheads entering a facility could be unloaded before verification, but this would create security issues that would be expensive to solve.

In practice, inspectors would likely need access to the warheads awaiting dismantlement *inside* assembly/disassembly facilities to verify that they really were warheads. The disassembly process itself could not be monitored without revealing extensive information about weapon design. However, warheads entering the process, as well as some of the components and empty storage containers leaving it, could be tracked in order to build additional confidence that those warheads had actually been dismantled.¹⁷⁷ Given the exceptional sensitivity of assembly/disassembly facilities, which were not designed to facilitate transparency, designing and implementing a credible verification system could prove challenging—and, once again, joint research would be required prior to negotiations.

Challenge inspections? The verification measures sketched out so far would be intended to ensure that a state had not understated the number of warheads stored at declared sites or the number it had dismantled. However, cheating could also take the form of retaining illicit stockpiles at undeclared sites—though NTM would probably be adequate for verification in this case. Even with a warhead limit in place, Russia and the United States would still retain a few thousand warheads apiece. Illicit stockpiles would have to comprise hundreds of warheads to be militarily significant. The equipment and activities needed to keep this number of warheads safe, secure, and effective would be difficult to hide from NTM and would be particularly noticeable at an undeclared site where nuclear warheads were not supposed to be present. Therefore, so-called challenge inspections to verify the absence of warheads at undeclared sites should not be necessary—which would boost the feasibility of the treaty because challenge inspections could be highly intrusive and difficult to negotiate.

A related difficulty would derive from the possibility of nuclear warheads' being stored illicitly in vehicles or buildings on a declared site but outside the inspection boundaries. In this case, it might be possible to grant each party some rights to verify such buildings and vehicles using a protocol like the one for verifying the absence of warheads at empty warhead storage facilities (see chapter 2). Indeed, inspecting such empty facilities would build useful experience for designing a warhead-limitation treaty.

Assessment

Technical feasibility. A treaty to limit all warheads would require substantially more intrusive inspections than either state has accepted before. One illustration of the scale of the challenge is that it took the United States five years, from 1998 to 2003, to negotiate access to Russian warhead storage sites as part of an agreement to upgrade their security. Even so, U.S. inspectors were ultimately not permitted to enter the storage facilities themselves; they could go only as far as the fence that surrounds them.¹⁷⁸

Reaching an agreement that allowed the inspection of warhead storage facilities and assembly/disassembly facilities would require access rights to be negotiated in great detail. A useful point of comparison is New START, which, including its protocol and annexes, is

356 pages long (the vast majority of which deals with verification). A warhead-limitation treaty would undoubtedly be even more complicated.

In negotiating such an agreement, Russia and the United States certainly have some relevant experience to build upon—most notably, the declarations and inspections of deployed strategic warheads pursuant to New START. However, inspections in storage facilities and especially assembly/disassembly facilities would create problems that require more unilateral and, more importantly, joint research to solve.

To that end, Russia and the United States should *individually* undertake the following tasks:

- Restart national research programs on warhead-level arms control, including on verification technology and inspection procedures.
- Identify potential changes to classification rules to facilitate warhead-level arms control and assess the benefits and risks of those changes on the assumption that they would be reciprocated by the other party and would apply exclusively to official U.S.-Russian data exchanges and inspection activities.
- Assess how much confidence NTM could likely provide that the other state had not illicitly retained any militarily significant stockpiles of warheads at undeclared sites in contravention of the warhead-limitation treaty proposed here.

Because these tasks would be undertaken unilaterally and the results could be kept classified, there is no reason why Moscow and Washington could not start on them immediately.

The two states should also undertake the following *cooperative* efforts, which would realistically require some improvement in their political relationship:

- Restart joint research on warhead verification, including on information barriers, and commit to the joint development and testing of such technology in the future.
- Start (or perhaps restart) joint studies on inspections at warhead storage facilities using tabletop exercises and commit to extending such studies to include on-the-ground exercises and assembly/disassembly facilities in the future.
- Negotiate reciprocal inspections to verify the absence of nuclear warheads at empty actual or suspected warhead storage facilities (see chapter 2).
- Negotiate a less detailed version of the baseline information exchange outlined above for implementation on a politically binding basis.
- Consider whether New START's replacement should limit all warheads located on ICBM, SLBM, and heavy bomber bases, whether deployed or in storage. The advantage of this approach, compared to New START, is that it would limit all

warheads deployed, or immediately available for deployment, on strategic delivery systems (not just the warheads located on ICBMs or SLBMs).¹⁷⁹ It would also build valuable experience with inspections of storage facilities. The disadvantage is that pursuing such a complex approach would risk derailing negotiations. Russia and the United States should therefore jointly assess its feasibility at the time those negotiations begin.

If U.S.-Russian political relations improve even modestly, the two states should agree to conduct joint research on an unconditional basis, not least as a minimal step to comply with the Nuclear Non-Proliferation Treaty's disarmament obligations. Other preliminary steps, such as inspections of empty storage facilities, would probably require a quid pro quo of some kind. If the two states could complete the lists of unilateral and cooperative activities, they would be well placed to start negotiations over a warhead limit—at least from a technical perspective.

Political feasibility. For the United States, a limit on all warheads is an attractive concept. It is consistent with the long-standing bipartisan goal of constraining Russia's large arsenal of nonstrategic nuclear warheads and with the Biden administration's stated objective of addressing "all of Russia's nuclear weapons."

In practice, however, if there were progress in negotiating such an agreement with Russia, some concerns would inevitably emerge. There would likely be some resistance in the United States and in the allied nations that host U.S. nuclear weapons to the unprecedented intrusiveness of—and the potential disruption caused by—inspections inside warhead storage facilities and particularly assembly/disassembly facilities (such concerns probably explain the Trump administration's focus on perimeter portal monitoring). There would also be domestic criticism over the non-inclusion of China. Indeed, substantial increases in China's arsenal, or even further evidence that China may be planning such increases, could complicate the political environment for U.S.-Russian arms control long before such increases changed the U.S.-Chinese deterrence equation.

In the final analysis, however, constraining Russia's nonstrategic weapons is a sufficiently important goal that these concerns would probably not be deal breakers. Indeed, the U.S. Senate might even provide its advice and consent for the ratification of a bilateral warhead-limitation treaty, especially if it did not mandate deep reductions. For the foreseeable future, Russia will continue to have a significantly larger nuclear stockpile than China and will likely remain the pacing *nuclear* threat. Meanwhile, there are more feasible—though still challenging—approaches to try to manage the buildup in China's nuclear arsenal, such as the proposed U.S.-Chinese fissile material cut-off agreement (see chapter 4). More generally, given the complexities of warhead-level arms control, it would be preferable to understand and try to solve the challenges on a bilateral U.S.-Russian basis before attempting to negotiate a trilateral treaty.

By contrast, under current circumstances, Russia is unlikely to support a comprehensive and verified warhead-limitation treaty, which would go far beyond the unverified one-year freeze in numbers that Moscow was prepared to accept in 2020. Certainly, Russian concerns about the United States' upload potential do not appear to provide a strong enough motivation.

One potential Russian concern is the non-inclusion of France and the United Kingdom (though past Russian insistence that those two states must be included in future arms control arrangements has evaporated quickly).¹⁸⁰ Another is likely the intrusiveness of inspections. Most fundamentally, however, Moscow views its large stockpile of nonstrategic warheads as a significant advantage that helps to compensate for its perceived conventional inferiority. It is unlikely to limit its warhead stockpile absent significant concessions by the United States.

Moscow has not indicated what the United States would have to trade for a warhead-limitation treaty. In fact, it has not indicated that a trade is even possible. Its long-standing position is that it will not negotiate over NSNWs until the United States has withdrawn all its nuclear warheads to national territory.¹⁸¹ NATO could not accept withdrawal as a prerequisite to negotiations, but it should discuss whether withdrawal could be an acceptable outcome of an arms control process that included a warhead-limitation treaty. Such a debate could prove contentious and would need to be carefully managed, including by agreeing at the outset that the alliance would only agree to withdrawal if it could reach consensus.

In this context, conventional arms control could provide important benefits to both NATO and Russia. Russia worries about its conventional inferiority across Europe as a whole, whereas NATO is concerned about its local inferiority in the Baltic region. Measures to address both imbalances—which may require managing the conventional and dual-use missiles previously constrained under the INF Treaty as well as general purpose forces—could help induce Russia to agree to a warhead cap and NATO to agree to the withdrawal of U.S. nuclear weapons from Europe.

A quite different approach would be to trade a warhead-limitation treaty for limits on ballistic missile defenses. Such a deal would not address the reasons why Russia maintains its large arsenal of nonstrategic warheads, but it might well provide more value to Moscow than the withdrawal of U.S. nuclear weapons from Europe and conventional arms control. Of course, U.S.-Russian negotiations over limits on ballistic missile defenses (which would apply equally to both Russian and U.S. capabilities) would be difficult, and the task facing the United States government in building sufficient domestic support to enable ratification even more so. Yet these challenges lay far in the future. For now, the first step is for Russia and the United States, in both official and unofficial dialogues, to creatively explore the potential trade space.

FINAL THOUGHTS

THE NINE proposals in this report speak for themselves; what does not is the challenge of generating the “political will”—to use a term beloved by diplomats—that will be needed to turn these proposals into reality. Part of the difficulty stems from the fraught relationships between the United States and China and the United States and Russia. Additionally, divisive internal politics create incentives for leaders not to seek cooperation with rivals, even when all parties could enjoy security benefits from arms control.

While there is no simple fix, it would be wrong to assume that political barriers are immutable. On October 14, 1962, the day before Soviet missiles were discovered in Cuba, it would have been unthinkable that, within a year, Moscow and Washington would establish a hotline intended to reduce the risk of nuclear war. In early 1985, when U.S.-Soviet negotiations on the INF Treaty had been suspended for almost eighteen months and hundreds of nuclear-armed missiles were deployed in Europe, it would have seemed far-fetched to suggest that a treaty prohibiting those missiles would be concluded by 1987. It is impossible to predict when opportunities for arms control will arise, but China, Russia, and the United States and NATO should consider and refine proposals now to enable rapid progress when the political conditions allow.

The key to making progress will be to craft arms control approaches that each party believes will benefit its specific interests—a requirement that is obvious but challenging to implement given the asymmetries and tensions among Chinese, Russian, and U.S. interests. One

potential solution is to package two or more measures together. An obvious combination, for example, would be to link a proposal on ballistic missile defenses to one on NSNWs, thus catering to both Russian and U.S. concerns. In this context, Beijing, in particular, should undertake the internal work needed to define what it might want from Washington (and Moscow too, perhaps).

At the same time, each state should ask itself whether its interests would be better served by a broader conception of its security goals—one that encompasses the prevention of arms racing and the mitigation of inadvertent escalation risks as well as the development of effective deterrence capabilities. Nuclear deterrence requires there to be some risk of escalation, otherwise a nuclear threat could never be credible; however, calibrating this risk to optimize a state's security can be difficult. Indeed, in today's world, the risks of escalation seem unnecessarily high. An incipient global nuclear arms race is only likely to add to the costs yet further. Arms control—undervalued and underexplored today—can be a powerful tool for better managing the risks inherent to enhancing security through threats of catastrophic destruction.

APPENDIX A

RANGE DEFINITIONS AND DETERMINATION

NEGOTIATING AN arms control agreement often involves agreeing how to define the concept of range. The parties need this definition to determine the ranges of both their own delivery systems and those belonging to the other party or parties.

One way to define range is in terms of the maximum distance flown by a weapon during testing. The INF Treaty, for example, defines the “range capability” of a type of ground-launched ballistic missile to be “the maximum range to which it has been tested.”¹⁸² This definition has the considerable virtues of clarity and ease of implementation. By the late Cold War, the United States and the Soviet Union were likely able to collect good data on the launch and impact points of one another’s ballistic missile tests. Based on this information, the range capability of each type of ground-launched ballistic missile could be determined with high confidence.

This approach suffers from some serious flaws, however. States may not always test ballistic missiles as far as they can fly, often because of geographical constraints. For example, China’s only realistic option for testing its ICBMs to anything like their full ranges would be to fire them eastward across the Pacific Ocean—but it has not done so since the 1980s, presumably out of restraint.¹⁸³ As such, its tests are typically conducted across a distance of roughly 2,500 kilometers (1,600 miles), even though its farthest-reaching ICBMs can fly about five times as far.¹⁸⁴ (In practical terms, China fires its ICBMs on so-called lofted trajectories—think fly balls in baseball—that reach great heights but do not travel all that far downrange.

Firing that same ICBM along a so-called minimum energy trajectory—the equivalent of a line drive—would cause it to travel significantly farther but at lower altitudes.)

The challenges are even greater with cruise and boost-glide weapons. The impact point of a ballistic missile is largely determined by its velocity when its engines burn out.¹⁸⁵ By contrast, cruise missiles can terminate their flight at any point along their trajectory; the same is basically true for boost-glide missiles once they have reentered the atmosphere. As a result, it is difficult for an observing state to determine whether one of these weapons has been tested to its maximum range. Moreover, unlike ballistic missiles during the unpowered portion of their flight, neither cruise missiles nor boost-glide missiles are constrained to travel along straight lines. As a result, the distance traveled during a test cannot be inferred from the launch and impact points alone.

The range of a cruise missile, therefore, has always been defined in terms of inherent capability rather than testing history. Both the INF Treaty and New START, for example, define it in essentially identical terms as “the maximum distance which can be covered by the missile in its standard design mode flying until fuel exhaustion, determined by projecting its flight path onto the earth’s sphere from the point of launch to the point of impact.”¹⁸⁶ New START takes a conceptually similar approach for ballistic missiles, defining the range of a given type to be “the maximum distance determined by projecting the flight trajectory onto the Earth’s sphere from the launch point of a missile of that type to the point of impact of a reentry vehicle.”¹⁸⁷

Such definitions are potentially challenging to operationalize because they require each party to model the other’s delivery systems. Indeed, it is not difficult to imagine disagreement between the parties over whether the range of a given delivery system was just above or just below some threshold. Moreover, resolving such disputes could prove difficult. It stretches credulity to imagine that one state could conduct a demonstration flight of, say, a cruise missile along a totally straight trajectory and allow inspectors to verify that the fuel tank was full before launch and that there was essentially no fuel at the impact site—but, even if it did so, there would be no practical way for inspectors to verify that the missile had flown along the altitude profile that would maximize the distance traveled.

Nonetheless, New START’s definitions for the ranges of cruise and ballistic missiles are the best available option going forward—not least because both parties have considerable experience in applying them. In practice, disagreements between the United States and the Soviet Union or Russia over the range of a missile have been rare. Moreover, the most notable exception—the dispute over the range of the SSC-8 ground-launched cruise missile—was not caused by an ambiguous definition or slight differences between the two states’ physical models of the weapon: Russia claimed that this weapon had a range of 480 kilometers, whereas, according to media reports, the official U.S. estimate was in excess of 2,000 kilometers.¹⁸⁸ Rather, the United States has (persuasively) argued that Russia has en-

gaged in outright noncompliance, whereas Russia has essentially accused the United States of peddling misinformation.¹⁸⁹

Defining and Determining the Range of Boost-Glide Missiles

Boost-glide missiles have not been limited under any previous arms control agreement, making it necessary to develop a definition for their range. We propose the following:

The range of a boost-glide missile is the maximum distance that can be flown by a missile of the same type, determined by projecting its flight path onto the Earth's sphere from the point of launch to the point of impact, assuming that its maximum speed does not exceed the maximum speed reached in any flight test of a missile of the same type.

This definition is similar to New START's definition for the range of a cruise missile with the important exception that the former embeds the assumption that, to ensure reliability, a state would want to test a glider at its maximum speed (but not necessarily across its full range).

Estimating the range of a boost-glide missile is likely more difficult than estimating the range of a ballistic missile (though easier than estimating the range of a cruise missile). The flight of a boost-glide missile, before it descends on the target, can be divided into four stages: (1) powered, (2) ballistic, (3) pull-up, and (4) gliding. During the powered and ballistic stages, a boost-glide weapon behaves similarly to a ballistic missile launched on a depressed trajectory. After release, the glider reenters the atmosphere (if it ever leaves it) and executes a pull-up maneuver to enable gliding. The total distance traveled by a boost-glide missile is the sum of the distances covered during each phase of flight.

Estimating the range of a boost-glide missile requires modeling both the rocket booster and the glider. The intelligence community has extensive experience modeling rocket boosters and hence phases 1 and 2 of a boost-glide missile's flight. The aerodynamic and other relevant properties of gliders can be estimated by observing flight tests. These properties then allow a model of phases 3 and 4 to be constructed.

Phase 4, the glide phase, typically represents both the largest contribution to the distance flown as well as the largest source of uncertainty about range. Although intelligence agencies likely use complex mathematical models to simulate gliding, the following approximation for glide range, l_{glide} , is useful for understanding which factors are the most important for determining it:

$$l_{glide} = \frac{r_e L}{2 D} \ln \left(\frac{1}{1 - (v_i/v_e)^2} \right)$$

Here, r_e is the radius of the Earth (approximately 6,400 kilometers or 4,000 miles), v_e is the speed of a satellite in low-Earth orbit (approximately 8 kilometers per second or 5 miles

per second), v_i is the initial speed of the glider, and L/D is the glider's lift-to-drag ratio.¹⁹⁰ The latter two quantities are key for estimating a glider's range. The lift-to-drag ratio is the relative strength of the lift and drag forces experienced by a glider. The larger this quantity or the initial speed, the farther a reentry vehicle can glide (but the more demanding heat management typically becomes).

There is a trade-off between the range covered in the ballistic portion of a glider's trajectory and the gliding portion. As a glider reenters the atmosphere, it must pull up to establish gliding. Executing this maneuver slows the glider and hence reduces the potential glide range. The larger the angle through which the glider pulls up, the more it slows. Boost-glide missiles are usually launched on a shallow trajectory that reduces the pull-up angle and thus increases glide range at the expense of reducing the distance traveled during the ballistic phase. Firing the missile on a more lofted trajectory increases the ballistic range but reduces the glide range. So, for a system tested to some maximum v_i , there is an optimal rocket trajectory that maximizes the total range.

As a glider passes through the atmosphere, some of its potential and kinetic energy is turned into heat, which increases the temperature of its skin, leading to the emission of infrared radiation in the same way that a hot stove element glows red. If this infrared signature is sufficiently strong, it could be detected with the space-based infrared sensors that China, Russia, and the United States deploy for ballistic missile early-warning, among other tasks.

There has been considerable debate about whether the United States can detect hypersonic gliders with its existing space-based early-warning architecture, which comprises newer Space-Based Infrared System satellites alongside a few remaining satellites from the legacy Defense Support Program constellation. The capabilities of these systems are classified, but in 2019, Michael Griffin, then undersecretary of defense for research and engineering, stated categorically that “we can't see these things [hypersonic threats] from a few spacecraft in geostationary orbit.”¹⁹¹ Other statements by U.S. officials, however, suggest that the newer satellites can, in fact, detect gliders, even if their capabilities are not adequate for all purposes. In 2021, for example, Michael White, the Department of Defense's principal director for hypersonics, critiqued claims that tracking is currently possible by noting the difficulty of monitoring a glider “precisely and continuously enough to help missile defenses set up an intercept”—a statement that actually appears to concede the premise he was attempting to undermine.¹⁹² Statements from U.S. officials that a June 2015 test of a Chinese boost-glide missile involved “extreme maneuvers” also appear to suggest that the United States already has some capability to track a glider in flight.¹⁹³ Independent studies have reached this same conclusion.¹⁹⁴ There is no publicly available information on the capabilities of Chinese and Russian early-warning satellites.

If a glider can indeed be tracked with space-based infrared sensors for a significant portion of its flight, then its properties—including the initial glide speed and lift-to-drag ratio—can be inferred, allowing the glide range to be estimated.

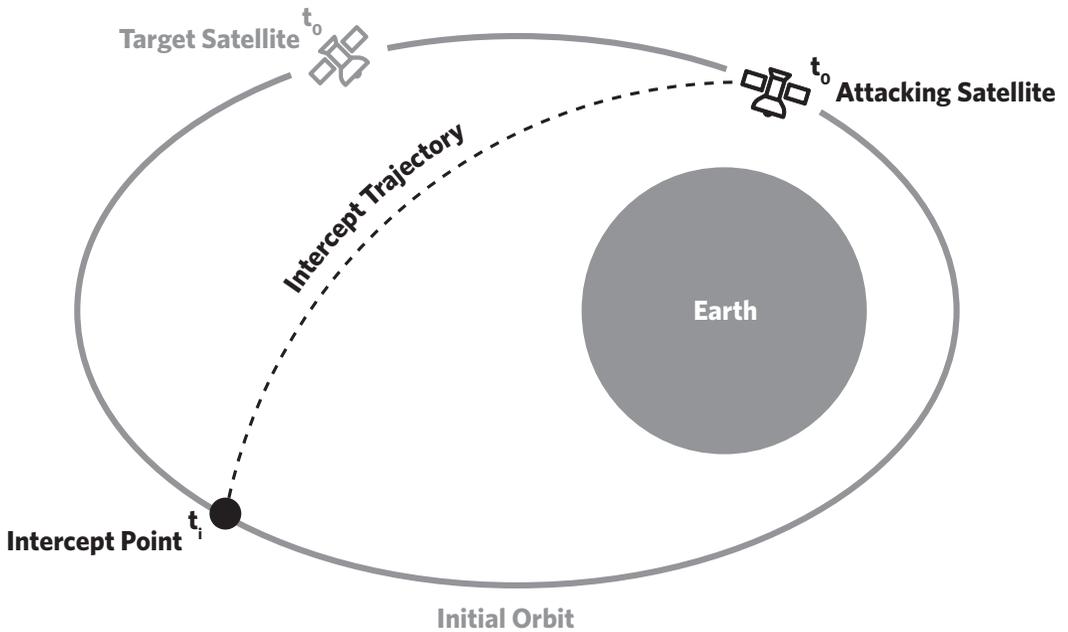
APPENDIX B

CHASE MANEUVERS IN GEOSTATIONARY ORBIT

SATELLITES ARE typically repositioned in a way that minimizes fuel consumption in order to maximize their service lives. For a co-orbital anti-satellite attack, however, minimizing the time-to-interception would likely be a more important goal to reduce the chance that the targeted satellite's owner would detect the attack while it was ongoing and instruct its satellite to take evasive action. So-called chase maneuvers enable an attacking satellite to directly approach a target satellite in a short amount of time at the cost of a large amount of fuel. The time needed for a chase maneuver in the case of a co-orbital anti-satellite weapon initially situated on the edge of a geostationary satellite's keep-out zone helps determine the requirements for verifying such zones (see chapter 6).

Consider an attacking satellite and a target satellite in the same initial orbit at time t_0 separated by some angle (see figure 1). The attacker aims for its satellite to intercept the target satellite at some future time, t_i . At t_0 , the attacking satellite moves from its initial orbit to the interception trajectory by applying thrust that results in a speed change, Δv . The satellite must apply the same thrust (in the opposite direction) at t_i to move back onto the initial orbit ahead of the rendezvous.¹⁹⁵ There are an infinite number of potential interception trajectories, each taking a different amount of time $\Delta t = t_i - t_0$ and requiring a different Δv . Faster intercepts require a greater Δv and hence more fuel. The total amount of fuel the attacking satellite has available is set by some “ Δv budget” (in other words, the total speed change it can effect over its remaining lifetime). For medium to large satellites,

FIGURE 1
Anatomy of a Chase Maneuver



this budget is typically in the range of 1–4 kilometers per second (0.62–2.5 miles per second) at the start of their service lives.¹⁹⁶

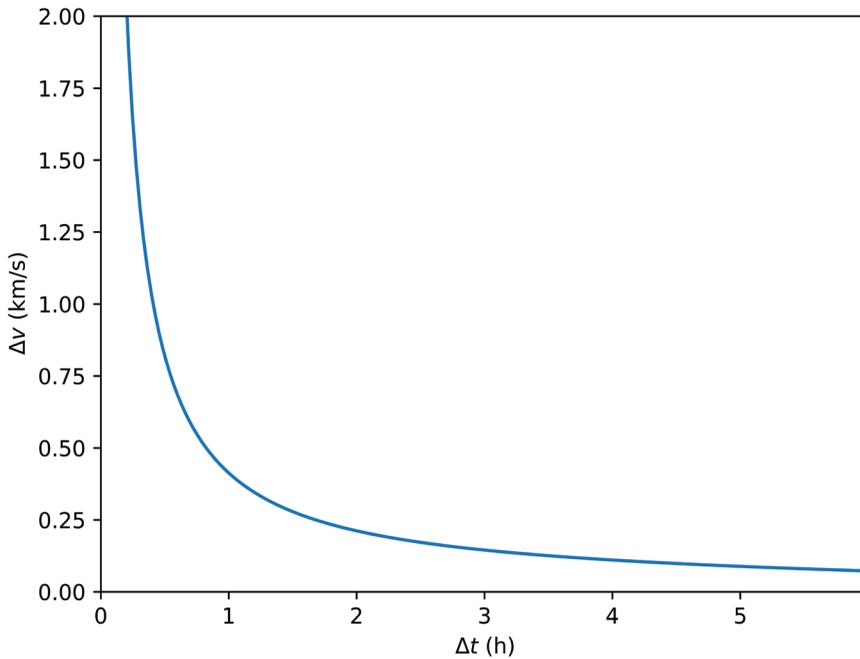
In practice, it would be unlikely that a co-orbital anti-satellite weapon could or would expend this entire budget in a single attack. Such a weapon would have to be launched before the attack—perhaps a considerable time in advance—and would likely have already expended some fuel on maneuvering. If the weapon were capable of being used more than once, the attacker might want to conserve sufficient fuel for follow-on attacks. Even if it were not, the attacker would still probably not want to use up all its fuel in the initial approach in case the target satellite undertook evasive maneuvering.

If two satellites in geostationary orbit are separated by 1 degree in true anomaly (720 kilometers or 450 miles), the fuel required, expressed as Δv , for the lagging satellite to execute a chase maneuver and catch up with the other is shown as a function of the maneuver time, Δt , in figure 2 (which is obtained by solving Lambert’s problem).¹⁹⁷ Very fast maneuvers—less than an hour or so—require a prohibitive quantity of fuel. Maneuvers potentially fast enough to catch the target before being detected by a space situational awareness system

making observations every 2–3 hours would require a speed change of approximately 0.2 kilometers per second (0.12 miles per second), representing the approximate amount of fuel expected to be used for station keeping in a geostationary orbit in a year.

FIGURE 2

Graph showing the required fuel, expressed in terms of the resulting change of speed (Δv in kilometers per second), to execute a chase maneuver in a given time period (Δt in hours) for a co-orbital anti-satellite weapon that is initially situated on the edge of a one-degree keep-out zone around a satellite in geostationary orbit.



AN OPEN-SOURCE ASSESSMENT OF CHINESE, RUSSIAN, AND U.S. SPACE SITUATIONAL AWARENESS CAPABILITIES

THE “REFRESH RATE” of a space situational awareness system—how often it views each satellite—helps determine the minimum warning time that a state would receive of an attack on one of its satellites and is thus an important factor in determining the verifiability of keep-out zones (see chapter 6). Space situational awareness capabilities would also contribute to verifying the prohibition on space-based missile defenses (see chapter 7), though in this case would be only one of several verification tools.

The frequency at which the Chinese, Russian, and U.S. space situational awareness systems can detect satellites cannot easily be estimated with open-source information because of the opacity around the relevant capabilities. Because some (perhaps many) modern satellites can transmit continuously to their owners, states presumably receive constant updates from those spacecraft. (So-called cross links between satellites enable communications from any that are not within range of the owner’s downlinks.) However, many satellites do not keep track of their own positions, which must be measured by the satellites’ owners. Moreover, effective space situational awareness requires monitoring other states’ satellites—not least those that could pose a potential threat to a state’s own satellites.

The following description of space situational awareness capabilities—although qualitative and based only on the limited information that is publicly available—is hopefully helpful in understanding their possible attributes and limitations and in identifying needed improvements, which Beijing, Moscow, and Washington have strong incentives to undertake

regardless of their participation in arms control. This account focuses on monitoring geostationary satellites. The more straightforward case of monitoring satellites in Molniya orbits is discussed briefly at the end.

Ground-Based Optical and Infrared Telescopes

A fixed ground-based telescope can image at most 45 percent of the geostationary belt. (Unlike low-Earth orbit satellites, which are in constant motion relative to the Earth's surface, geostationary satellites remain fixed above the same point on the ground.) Achieving full coverage of the geostationary belt with ground-based sensors therefore requires at least three sites spread around the Earth's equator.

Ground-based optical telescopes are widely used to track satellites in geostationary orbit. Their inability to detect satellites during the day, however, creates significant gaps in coverage that co-orbital anti-satellite weapons could exploit. The duration of this gap, which is twelve hours on average, varies with latitude and season, so hemispheric diversity can mitigate this problem—but only to some extent. Moreover, because an individual optical measurement cannot determine the altitude of a satellite, it cannot be used to infer the relative speeds of two satellites (although it could determine whether one satellite had entered the keep-out zone of another). Estimating a satellite's altitude requires extended observations, observations from multiple locations, or the illumination of the satellite with a laser (which requires more complex and expensive equipment).

The ongoing development of shortwave infrared telescopes has made it possible to observe geostationary satellites during daylight.¹⁹⁸ There likely remains, however, some portion of the day when a satellite is too close to the sun to be imaged in this way. Moreover, no ground-based telescopes (visible or infrared) can operate when the weather is overcast, as clouds are opaque to the relevant wavelengths (though spacing telescopes geographically, even at similar longitudes, creates some resilience to weather effects).

Russia has access to the most extensive network of optical telescopes, including dedicated military facilities in the North Caucasus, the Altai Republic, and Tajikistan.¹⁹⁹ The U.S. Ground-Based Electro-Optical Deep Space Surveillance system includes optical telescopes located in the continental United States, Hawaii, and the British Indian Ocean Territory.²⁰⁰ China operates optical sensors at its Purple Mountain Observatory and has negotiated a number of international partnerships, including with Chile, Mexico, and South Africa, to improve the latitudinal diversity of the telescopes at its disposal.²⁰¹ In addition, commercial actors have developed ground-based telescope networks that rival those of governments.²⁰² It is possible that governments have plans to use such capabilities to supplement their own in a crisis or conflict.

Space-Based Optical Sensors

Optical sensors on satellites avoid some of the weaknesses of ground-based sensors, though require significantly more investment. Space-based sensors are not affected by terrestrial weather. Moreover, a single satellite can survey, over time, the whole of the geostationary belt from an orbit in which it moves relative to that belt.

Some optical imaging sensors—such as the U.S. Space-Based Visible sensor aboard the Midcourse Space Experiment satellite and its successor, the Space Based Space Surveillance satellite—are located in low-Earth orbit.²⁰³ Every geostationary satellite is within the line-of-sight of such sensors at least once during each sensor’s orbital period (approximately ninety minutes). Geostationary satellites cannot be observed from low-Earth orbit, however, during periods when they are too close to the sun. Canada’s NEOSat satellite, for example, cannot observe objects located within 45 degrees of the sun, creating a six-hour period each day when it cannot image a given geostationary satellite.²⁰⁴

Optical sensors can also be placed on high-altitude satellites. The U.S. Geosynchronous Space Situational Awareness Program constellation, for example, comprises four satellites—two just above and two just below geostationary orbit—which rotate in opposite directions relative to the geostationary belt.²⁰⁵ Optical sensors in near-geostationary orbits still have exclusion zones, but they generally occur at different times from those for sensors on the ground or in low-Earth orbit. They also survey the geostationary belt at a lower cadence than low-Earth orbit satellites since their orbital periods are closer to the geostationary orbital period. Increasing the number of high-altitude optical sensors ameliorates both exclusion and cadence issues.

Russian inspector satellites, located in both low-Earth and geostationary orbits, may have surveillance capability, though perhaps of quite limited range.²⁰⁶ The Tundra early-warning satellites may also have some space surveillance capability.²⁰⁷

Ground-Based Radio Telescopes

Radio telescopes can be used to intercept downlink or broadcast radio-frequency signals from a high-altitude satellite, allowing for its position to be calculated through triangulation. (States also have dedicated downlinks to receive signals from their own satellites, but, in general, these are poorly located for detecting signals from foreign satellites in geostationary orbit.) The operations of radio telescopes are not significantly affected by terrestrial weather and are entirely unaffected by the day-night cycle. Radio telescopes can only detect satellites that are actually broadcasting—but especially in a crisis or conflict, the high-altitude satellites involved in nuclear command-and-control would almost certainly transmit continuously (though if any of these satellites rely exclusively on laser communications,

they could not be monitored at all with radio telescopes). As with other ground-based assets, a number of suitably spaced radio telescopes are needed to provide coverage of the whole of the geostationary belt.

Russia has an extensive network of large radio telescopes, while China has recently built one in Argentina to expand its coverage.²⁰⁸ Official U.S. descriptions of its space surveillance network do not mention radio telescopes, but some U.S. observatories could be used for space situational awareness.²⁰⁹

Ground-Based Radars

Ground-based radars illuminate satellites with radio, or microwave, frequency radiation to measure their direction and range. Radars capable of detecting satellites in high-altitude orbits have small fields of view (generally a fraction of a degree) and relatively long measurement times (on the order of minutes).²¹⁰ As a result, they are poorly suited for wide-area monitoring but can accurately locate objects whose positions are known approximately (such as a satellite that has not conducted a repositioning maneuver since it was last observed). Like ground-based radio telescopes, they are not affected by either the day-night cycle or terrestrial weather.

There is uncertainty about the extent of Russia's and particularly China's deep-space radar capabilities. Russia's Deep Space Network radio telescopes have been used in experiments as radar receivers for detecting space debris in high-altitude orbits, suggesting that Russia has at least some capability to monitor satellites in those orbits with ground-based radars.²¹¹ China, meanwhile, possesses radars capable of observing low-Earth orbit satellites, but it is not known whether it also has radars capable of imaging satellites in high-altitude orbits.²¹²

The United States possesses at least three radars capable of detecting high-altitude satellites: ALTAIR in the Marshall Islands, Millstone Hill in Massachusetts, and Globus II in Norway. If the field of view for each radar extends 60 degrees either side of the local vertical, this network should cover the entire geostationary belt, except for a gap between 70 degrees east to 110 degrees east—very roughly from India to Vietnam. This gap is home to about thirty of the one hundred Chinese, Russian, and U.S. satellites in geostationary orbits. (It is possible that, because of power limitations, the field of view for each radar is smaller than 120 degrees, which would increase the size of the coverage gap.)

Gaps in Coverage for a Space-Situational Awareness System

If a high-altitude satellite and any nearby objects belonging to other states cannot be monitored by any remote sensing system, violations of the satellite's keep-out zone could not be detected. Such a situation can occur if the satellite is located outside of the fields of view of all of a state's sensors. There are also temporal gaps—when a satellite is located too

close to the sun, for example—during which even suitably located sensors cannot function effectively.

These challenges are particularly acute for geostationary satellites, which do not move much relative to the Earth's surface. Ground-based visible telescopes cannot observe any satellites during daytime. Moreover, around local noon, a geostationary satellite may be too close to the sun to be observable by ground-based infrared telescopes or by optical sensors in low-Earth orbit. How long these exclusion periods last depends, in part, on the design of each individual sensor, which is generally classified—though, if NEOSSat is anything to go by, the periods may last for several hours.²¹³ An aggressor could conduct an attack during a gap without risk of detection. The duration of these gaps may be reduced by adding additional optical or infrared sensors on the ground or on satellites in low-Earth orbit. Depending on the size of each sensor's exclusion zone, however, it may not be possible to eliminate them entirely.

Closing gaps requires substantially more sophisticated and expensive technology than ground-based telescopes or sensors in low-Earth orbit. Optical sensors in high-altitude orbits (particularly orbits above the geostationary belt) are useful, as a given satellite is generally back-lit at different times from when it is observed from low-Earth orbit or the ground. Ground-based radars and radio telescopes are other options. Although the latter can only detect a satellite while it is transmitting and a co-orbital weapon might not transmit during an attack, radio telescopes could still be useful in verifying that a potentially hostile satellite has not moved.

Molniya Orbits

Satellites in Molniya orbits spend most of their time high above the Northern Hemisphere, before quickly traversing the Southern Hemisphere at low altitudes. Observing such satellites is largely similar to observing satellites in geostationary orbit with three major exceptions. First, because satellites in Molniya orbits move relative to the ground, their trajectories can be more easily measured by a single sensor without the need for triangulation. Second, Molniya orbits are inclined by 63 degrees, so satellites in such orbits appear to be more distant from the sun than geostationary satellites, facilitating their monitoring with optical sensors based on the ground and in low-Earth orbit. Third, Chinese, Russian, and U.S. ground-based space situational awareness assets appear to be sparser in the Southern Hemisphere, through which satellites in Molniya orbits transit. However, because such satellites are traveling at high speeds during this part of their trajectory, they are probably more difficult to attack than when they are moving through the Northern Hemisphere and can be more easily observed from the ground.

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