Modernizing the Nuclear Triad: Decline or Renewal?

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Cover: An artist’s rendering of the future Columbia-class ballistic missile submarine, 2019. (US Navy)
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The author would like to thank Captain (Retired) Karl Hasslinger for reviewing and commenting upon drafts of this report.

Special thanks are owed to the good shepherd, Carolyn Stewart, who guided us flawlessly through the publication process. The author would also like to thank Julia Miller for research support. Last, but certainly not least, thanks are owed to the report’s editor, Terry Cummings, for enhancing both its style and substance.

The opinions and analysis in this study are those of the author; any shortcomings are his alone.
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<td>Chinese Communist Party</td>
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<tr>
<td>GBSD</td>
<td>Ground-Based Strategic Deterrent</td>
</tr>
<tr>
<td>HEU</td>
<td>Highly Enriched Uranium</td>
</tr>
<tr>
<td>ICBM</td>
<td>Intercontinental Ballistic Missile</td>
</tr>
<tr>
<td>IRBM</td>
<td>Intermediate-Range Ballistic Missile</td>
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<tr>
<td>LRSO</td>
<td>Long-Range Standoff (Cruise Missile)</td>
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<tr>
<td>MIRV</td>
<td>Multiple Independently Targetable Reentry Vehicle</td>
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<tr>
<td>MRBM</td>
<td>Medium-Range Ballistic Missile</td>
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<tr>
<td>MT</td>
<td>Metric Tons</td>
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<tr>
<td>NC3</td>
<td>Nuclear Command, Control, and Communications</td>
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<tr>
<td>PLA</td>
<td>People’s Liberation Army</td>
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<tr>
<td>SALT</td>
<td>Strategic Arms Limitation Treaty</td>
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<tr>
<td>SLBM</td>
<td>Submarine-Launched Ballistic Missile</td>
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<td>SS</td>
<td>Surface-to-Surface</td>
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<tr>
<td>SSBN</td>
<td>Fleet Ballistic Missile Submarine</td>
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<td>START</td>
<td>Strategic Arms Reduction Treaty</td>
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This study analyzes the United States’ plans for modernizing the land, sea and airborne legs comprising its strategic nuclear force triad. This force has been charged primarily with deterring a nuclear attack on the United States, its allies, and security partners (“extended deterrence”), and mitigating the consequences should deterrence fail.

Revisionist great powers China and Russia are both fully engaged in modernizing and, in China’s case, expanding their nuclear triads. Another hostile nuclear state, North Korea, continues expanding its nuclear arsenal, as does Pakistan, whose nuclear program continues receiving support from its long-term sponsor, Beijing. By comparison, the United States has barely moved from the starting gate, as its modernization effort is in its early stages and will not be completed until the mid- to late-2030s, and only then if all goes as planned.

When the US triad of land-based intercontinental ballistic missiles (ICBMs), ballistic missile submarines (SSBNs), and long-range heavy bombers was formed three score years ago, it was as much the result of accident than design. The result, however, has been serendipitous, as each leg has strengths that offset the weaknesses of one or both of its sister components. Simply put, the combined deterrent effect of the triad is greater than the sum of its individual components.

Each leg of the existing triad is rapidly reaching its “expiration date.” The land-based Minuteman III ICBMs were fielded roughly half a century ago, and America’s B-52 bombers predate the Minutemen. The Ohio-Class boats comprising the SSBN force were built roughly forty years ago and will need to be retired later this decade. Options for extending the life of each of these systems at less cost than replacing them have been exhausted.

The Defense Department’s plan calls for replacing the 400 Minuteman III missiles with an equal number of Ground-Based Strategic Deterrent missiles; replacing the 14 Ohio-class SSBNs with 12 Columbia-class boats; retiring the aging B-1 and B-2 bombers and replacing them with 100 or more B-21 bombers; upgrading the B-52 bomber’s air-launched cruise missiles with modern long-range standoff versions; and overhauling its nuclear command, control and communications systems.

Despite the ongoing modernization and expansion of rival state nuclear arsenals and the success the US triad has had in deterring nuclear war, the modernization effort has attracted criticism from some quarters, especially from those in the arms control community. Their ranks have been boosted by support from some current and former senior policymakers. Many express concerns that the modernization’s price tag of $264 billion for the land-based version, and as much as $1.5 trillion overall during these systems’ life spans, places an excessive burden on defense spending in particular, and the Federal budget in general. Alarms have been raised over the risk that modernization will reduce crisis stability, thereby compromising deterrence. Skeptics also assert that the United States can achieve the triad’s traditional objectives equally well by moving to a dyad of submarines and bombers. Some believe that if the ICBM force must be maintained, it should be done by extending the life of the existing Minuteman force, not replacing it. Many critics assert that moving forward with modernization risks triggering an arms race.

This assessment finds the critics’ arguments opposing triad modernization generally unpersuasive.

Arms Race
If there is an arms race, the United States has barely moved off the starting line. Russia and China are well along in modernizing their triads, while the Chinese are expanding theirs as well. Rather than pacing an arms race, the United States is in the position of playing catch up.

Cost and Cost Imposition
The program’s cost is not trivial, but neither is it extravagant. The modernization effort will consume less than 4 percent of the
defense budget at its highest point in the late 2020s and early 2030s. Overall, the Defense Department projects it will spend less than 10 percent of its budget annually on operating, sustaining, and modernizing the country’s nuclear deterrent.

Critics of the program’s cost tend to ignore the fact that a good strategy imposes disproportionate costs on rivals, making them less willing to pursue the competition, or to do so at a significant disadvantage. The triad modernization program’s land-based missile force and long-range bomber fleet act to impose costs on both China and Russia. The GBSD force does this by presenting them with an unfavorable attack weapon exchange ratio of 2:1 or (likely) worse. Defending against the bomber force requires enemies to expend resources as much as an order-of-magnitude greater than those required to field and maintain the bombers—and generally without success.

### Crisis Stability

Concerns relating to crisis stability center primarily around fears that the ICBMs will be forced to assume a hair-trigger launch posture. This stems from their fixed locations, which are well known to enemies, and their short attack warning time—perhaps 20 minutes or so before the incoming enemy warheads arrive. Hence the assumption that these missiles must be launched on warning of an attack, requiring them to be on high alert, thereby increasing the risk of an accidental or unauthorized launch. This, however, misses the point regarding the land-based deterrent’s principal value: as a deterrent force, not a warfighting force. By imposing disproportionate costs on an attacker, the ICBM force reduces an enemy’s incentive to attack, thereby enhancing deterrence. Simply stated, the land-based deterrent’s principal value rests in its ability to deter an attack, rather than being launched in the wake of an attack—in deterring a nuclear war, rather than fighting one. More broadly speaking, the triad’s mutually reinforcing components, where each leg has unique advantages that offset the shortcomings of the other two, greatly complicates an enemy’s planning and, in so doing, reduces the risk of war.

### Cutting Back to a Dyad

Those who advocate eliminating the triad’s land-based leg in favor of a dyad of bombers and submarines have not presented a compelling argument for why the land-based leg detracts from deterrence or that it is prohibitively costly. Nor have they explained how concentrating America’s nuclear “eggs” in a few submarine “baskets” strengthens deterrence. Nor, if the triad’s primary objective is to deter China and Russia, do critics explain why Chinese and Russian leaders believe modernizing their triads is important to ensure they possess a robust deterrent.

The SSBN leg of the triad is currently the most survivable, at least those submarines on patrol at sea. Yet concentrating the United States nuclear forces in one leg of the triad assumes that in this age of dynamic technological advances, there will be no major advances in undersea detection technology or threats to SSBN command-and-control links.

### A Vastly Different Tomorrow?

Many critics’ arguments against modernizing the US nuclear deterrent are rooted in assumptions that the current competitive environment—dominated by the twin US and Russian arsenals that are constrained by New START and populated by a handful of far lesser nuclear powers—will endure and remain in place at the time US triad modernization is completed nearly twenty years hence.

These assumptions are increasingly fanciful. Indeed, it’s far more likely that the strategic nuclear competition will have experienced several disruptive shifts by the mid-2030s.

### A Tripolar Nuclear Great Power Rivalry

US policymakers cannot discount the US-Russian bipolar nuclear competition becoming tripolar, with China joining them in the first rank of nuclear powers. Evidence is growing that China is determined not to be a second-class citizen regarding nuclear arms. Exhibit A is its ongoing nuclear modernization and expansion program, which is projected to at least double Chi-
na’s nuclear arsenal by decade’s end. This would square with China’s developing the DF-41 ICBM, capable of carrying ten warheads, and constructing over 200 new missile silos while fielding a separate road-mobile ICBM force.

If a tripolar great nuclear power regime were to emerge, parity—long a key component of Russian-US arms control agreements—would no longer be possible for each of the three nuclear giants. Correspondingly, establishing and maintaining a US deterrent capable of providing an assured destruction capability against two comparably armed powers would prove challenging. Doing so while preserving today’s level of deterrence seems especially daunting.

Breakout
There exists significant potential for breakout—a relatively rapid and significant shift in the nuclear balance. China is unconstrained by New START and nothing precludes the Chinese from stockpiling missiles or warheads. The large number of missile silos now being constructed in China could house a few missiles, or many. Similarly, the People’s Liberation Army (PLA) could easily expand its mobile launch systems. The Russians have a new ICBM that can accommodate four MIRVs, and another under development that can be armed with ten or more. They also clearly have sufficient fissile material stocks to support a rapid expansion of their arsenal.

Second-Tier Nuclear Powers
If the New START agreement is sustained over time, perhaps even incorporating a Chinese strategic nuclear force, then lesser nuclear powers could be incentivized to expand their arsenals to enhance the value of their geopolitical alignment. If so, the United States could be confronted with establishing an assured destruction capability against Russia and China while having to address the threat posed by second-tier North Korean (and perhaps Pakistani) arsenals if they were to align with China.

If the New START regime were to collapse in the wake of a Chinese ascent to great nuclear power status, an arms race could ensue. If so, prospective second-tier nuclear powers would have far less incentive to expand their arsenals to the high triple digits, similar to the British, Chinese, and French Cold War-era forces, since they would exert only an extremely modest influence on the competition among the great nuclear powers.

Multidimensional Strategic Forces
Nor can US policymakers ignore the emergence of multidimensional strategic arsenals, enabled by the growing number of non-nuclear precision-strike forces capable of attacking with confidence a significant number of strategic targets once reserved for nuclear forces. Moreover, as recent events suggest, cyber weapons also have the potential to hold at risk key elements of advanced states’ critical infrastructure. Nor should the prospect of non-nuclear hypersonic missiles be discounted, as they may come to exert a significant influence on the strategic balance.

The Bottom Line
Current circumstances strongly support triad modernization. Likely shifts in the character of the strategic competition—both geopolitical and military technical—serve only to increase the value of proceeding. Indeed, given current trends it would, at the least, seem prudent to hedge against the prospect that some will quite likely play out. If so, the United States’ options for addressing such shifts in the threat environment would be greatly enhanced by maintaining a modern nuclear deterrent sustained by a healthy industrial base.
I. INTRODUCTION

The triad of strategic delivery systems continues to have value. Each leg of the nuclear triad provides unique contributions to stability. As the overall force shrinks, their unique values become more prominent.¹

—William J. Perry,
Secretary of Defense
Clinton Administration

—James R. Schlesinger,
Secretary of Defense
Nixon and Ford Administrations

The United States is planning to modernize its strategic nuclear deterrent for the first time since the Cold War ended over thirty years ago. The deterrent comprises three main components, or "legs": land-based intercontinental ballistic missiles (ICBMs), distributed in hardened silos throughout the northern Midwest; fleet ballistic missile submarines (SSBNs) operating from two bases, one on each coast; and long-range bombers positioned at three air bases in the continental United States. These three legs are known collectively as the triad.

The modernization program has generated strong political support—and opposition. With respect to the latter, concerns center primarily on issues relating to the triad’s contribution (or lack thereof) to deterrence and “crisis stability,”² and its cost.

Photo: An unarmed Minuteman III intercontinental ballistic missile launches during an operational test at Vandenberg Air Force Base on February 25, 2016. (US Air Force)
This assessment examines these and related issues with an eye toward promoting an informed discussion of the modernization effort. It finds that the debate suffers from excessive emphasis on circumstances and capabilities as they exist today, or over the near-term future, while understating the possibility—indeed, the likelihood—of a disruptive shift in the strategic competition over the next decade or two, driven primarily by geopolitical and military-technical factors.

In brief, the US modernization effort must be judged not only against current rival capabilities, but against anticipated developments in the competition that may reasonably be expected to occur over the next two decades. This assessment is structured with this point at its core.

The US strategic nuclear deterrent’s primary objectives are consistent with those that have guided American nuclear strategy for well over half a century: deterring a nuclear attack on the United States as well as on its allies (“extended deterrence”); deterring rival attempts to use nuclear weapons as instruments of coercion, including coercion of America’s allies; and limiting the damage in the event deterrence of nuclear use fails.4

The need to deter a nuclear war rather than risk fighting one became clear during the early 1950s, after Soviet Russia had accumulated a significant number of fission weapons and tested a thermonuclear device. At that time, President Eisenhower observed that with respect to nuclear war, “There is no victory except through our imaginations.”5 President John F. Kennedy echoed his thoughts, declaring that in a major war involving nuclear weapons, “even the fruits of victory would be ashes in our mouth.”6 Decades later, President Ronald Reagan concluded, “A nuclear war cannot be won and must never be fought.”7

As the two nuclear superpowers’ arsenals increased in size during the Cold War, each strived to ensure that it could survive an attack (“first strike”) by the other and still retain sufficient nuclear weapons to inflict unacceptable damage on its rival in a retaliatory (or “second”) strike. This concept, known as assured destruction, has become a cornerstone of the US approach to deterrence. It holds that deterrence is enhanced if, in the minds of its adversaries, the United States retains the ability to inflict massive damage on their societies, even following a surprise first strike against US nuclear forces.8 If both rivals achieve an assured destruction capability, the effect is mutual. Robert Oppenheimer likened “mutual assured destruction” to the situation existing between two scorpions in a bottle: each having the ability to kill the other, but only at the risk of losing its own life.

Why a Triad?

Although as much the product of accident (through bureaucratic maneuvering) as design, the US triad has endured for over three score years primarily due to the combined characteristics of its three components. Each leg has unique advantages that enable it to offset shortcomings in the other two legs. The land-based Minuteman III ICBM force is the triad’s least expensive and most responsive leg. These missiles, however, are positioned in fixed, hardened silos, making them relatively vulnerable to an enemy surprise attack. Because US SSBNs are mobile and difficult to detect, they are currently the most survivable leg of the triad. They are also the most expensive leg and arguably the most difficult with which to communicate. The US bomber component has greater flexibility in both its deployment and weaponry than the other two legs. Bombers alone can be recalled after the decision has been made to launch the force. Since they are recallable, sending them airborne can send a formidable deterrent signal to rivals. Yet the bombers are likely to be far easier for enemies to intercept than are the ballistic missiles comprising the sea- and land-based legs of the triad.

Through their mutually reinforcing characteristics, this combination of delivery systems creates a deterrent effect greater than the sum of its component parts. As nuclear strategist Lawrence Freedman concluded, “There is an obvious danger of putting all
[nuclear] ‘eggs in one basket.’ If the deterrent depended solely on one type of delivery vehicle, then the adversary’s defensive problem would be simplified. To mount an attack simultaneously on three completely different types of system would be an awesome task.”

The US Modernization Program
All three legs of the US triad are long in the tooth. The land-based Minuteman III ICBMs were fielded over half a century ago. The oldest Ohio-class SSBN was launched in the early 1980s. The B-52 bomber, the mainstay of the airborne leg, was built in the 1960s. The United States’ “newest” bomber, the stealthy B-2, is based on a 1970s’ design. Only a handful (twenty) are in service.

It’s not surprising, therefore, that the Defense Department has plans to modernize the triad. The Air Force plans to have a new “Ground-Based Strategic Deterrent” (GBSD) ICBM force in place by the mid-2030s, while a new bomber, the B-21 Raider, should be entering the force around the end of this decade, along with a new cruise missile to extend the B-52’s service life. The Navy’s Columbia-class submarine is set to begin replacing the aging Ohio-class boats during the 2030s.

Structure
This assessment begins by providing an overview of the current state of the nuclear competition, thereby establishing a baseline for developing the topic. Its principal focus is on how the revisionist great powers, Russia and China, view the competition, and on their current strategic nuclear force modernization efforts.

The assessment then turns to the US modernization plan, presenting the critics’ principal concerns and evaluating their validity. An overview of four prospective disruptive shifts in the strategic balance follows. Several of them have a better-than-even chance of occurring between now and the time the US triad’s modernization is projected to be completed. The assessment closes with some findings and recommendations.
II. THE CURRENT STATE OF THE COMPETITION

Soviet spending… has shown no response to US restraint—when we build, they build, when we cut, they build.¹⁰

—Harold Brown, Secretary of Defense, Carter Administration

Despite the PRC’s dramatic build-up of its nuclear arsenal, unfortunately it continues to resist discussing nuclear risk reduction bilaterally with the United States.¹¹

—Ambassador Robert Wood¹², Biden Administration

US policy-makers generally accept that the era of US geopolitical and military dominance that characterized the two decades following the Soviet Union’s collapse is now over. Repeated efforts to reset relations with Russia have failed, as have attempts to create win-win engagements with China within the framework of the liberal international order. Both Beijing and Moscow have revealed themselves as revisionist powers seeking to overturn the existing order rather than participating in it. Hence, we have the return of active great power competition.

Not surprisingly, this competition extends across all dimensions of power, including the military sphere in general and nuclear weapons in particular. To date, the nuclear competition has been decidedly one-sided. While the United States has not de-

Photo: Composite of three images, left to right: The Ohio-class ballistic missile submarine USS Alabama (SSBN 731) returns home to Naval Base Kitsap-Bangor following a strategic deterrent patrol. (US Navy); An unarmed Minuteman III intercontinental ballistic missile launches from Vandenberg Air Force Base on February 5, 2020. (US Air Force); A B-2 Spirit flies over Whiteman Air Force Base on November 8, 2015. (US Air Force)
ployed a single new strategic nuclear system in the twenty-first century, and is only now in the early stages of modernizing its strategic deterrent, both China and Russia are well on their way to modernizing their nuclear triads, with China expanding its arsenal as well. The current situation is reminiscent of the late 1970s, when Defense Secretary Harold Brown declared, “Soviet spending… has shown no response to US restraint—when we build, they build, when we cut, they build.”

What is driving Beijing and Moscow to enhance all elements of their strategic triads while their American rival sits debating the merits of following suit? Part of the answer lies with how China and Russia view the nuclear competition. What role do they see their nuclear forces playing, and does this square with how they are pursuing their nuclear modernization efforts? Addressing these issues is this chapter’s primary focus.

**Russian and Chinese Views**

Generally speaking, Russian and Chinese political and military leaders have significantly different views from their US counterparts regarding the principal roles their nuclear forces will play in advancing their interests. These differences have important implications for deterrence and, by extension, the US nuclear posture.

**Russia**

Russian views regarding nuclear weapons’ use in particular, and strategic warfare in general, tend to be more expansive than those of their American rivals. In the post-Cold War era, Russian military strategists and senior leaders were faced with offsetting the challenge posed by the US-led Precision Warfare Revolution. This revolution, first manifested in the 1991 Gulf War, is centered on aerospace operations that combine extended-range precision-strike forces with space-based systems and computer-assisted command, control, and communications functions. These combine to form what Russian military theorists call a “reconnaissance-strike complex.” There is general acceptance among American, Chinese, and Russian military experts that certain types of precision strikes can achieve strategic effects comparable in effectiveness to those created by nuclear weapons. In particular, the Russians express concerns that a large-scale US aerospace campaign employing precision-guided munitions alone could cripple Russia’s economic and military infrastructure.

In part due to the US lead in precision warfare and the collapse of Russia’s conventional military forces following the Soviet regime’s dissolution in the early 1990s, Moscow refused to rule out responding to a non-nuclear attack with nuclear weapons. This is particularly the case in a war where the regime believes the state’s existence is at risk. Under these circumstances, Russia’s nuclear weapons could be employed as a way of signaling to Washington that it must de-escalate the war or face a heightened risk of escalating to nuclear Armageddon. This doctrine is sometimes described as “escalate to de-escalate.”

This nuclear doctrine has been sustained over time. In 2009, the head of Russia’s Security Council declared that his military had the option to launch a “preemptive nuclear strike” against an aggressor employing “conventional weapons in an all-out, regional, or even local war.” A year later Moscow declared it “reserves the right to utilize nuclear weapons in response to the utilization of nuclear and other types of weapons of mass destruction against it and (or) its allies, and also in the event of aggression against the Russian Federation involving the use of conventional weapons when the very existence of the state is under threat.”

Last year the government of President Vladimir Putin released “On Basic Principles of State Policy of the Russian Federation on Nuclear Deterrence.” It states reassuringly that Russia “considers nuclear weapons exclusively as a means of deterrence” and that its nuclear doctrine “is defensive by nature, it is aimed at maintaining the nuclear forces potential at the level sufficient for nuclear deterrence, and guarantees protection of national sovereignty and territorial integrity of the State, and
deterrence of a potential adversary from aggression against the Russian Federation and/or its allies.” Reflecting the importance of maintaining an assured destruction capability, the policy statement notes that Russia’s nuclear forces could “inflict guaranteed unacceptable damage on a potential adversary… in any circumstances.” Finally, Putin’s June 2020 policy once again reaffirms that nuclear weapons can also be used in the event of aggression against the Russian Federation with conventional weapons if the state’s existence is perceived to be in jeopardy. As Russian military exercises include simulating the use of nuclear weapons against NATO, this would appear to confirm that Russian doctrine calls for employing its nuclear forces at a far lower threshold than responding to a nuclear attack.

China
The Chinese term for deterrence—weishe—is more expansive than that typically used in Western defense circles. The People’s Liberation Army (PLA) textbook, *The Science of Military Strategy*, describes deterrence as having two objectives. The first involves discouraging an opponent from pursuing a particular course of action, and is similar to the Western definition. The second objective is to coerce an opponent into pursuing a course of action it would otherwise not undertake. Thus, weishe includes the Western concept of compellence. This suggests that the Chinese Communist Party (CCP) has more ambitious goals for its nuclear forces than US policy-makers do. It raises the questions of how the CCP would use its nuclear capability to coerce its rivals. One obvious use would be to undermine US extended deterrence. It also begs the question of what kind of nuclear arsenal the Chinese believe they need to pursue coercion.

Like the Russians, the Chinese view strategic warfare as encompassing more than nuclear weapons. Thus, China has pursued its own offset path to counter what it sees as the threat posed by US reconnaissance-strike complex operations. Unlike the Russians, who have sought to increase their emphasis on nuclear weapons as their principal response, the CCP is pursuing a combination of capabilities that include nuclear forces, “informatized” conventional forces, information warfare forces, a flexible space force, and something it refers to as an “innovative and developmental civilian deterrence force.”

According to *The Science of Military Strategy*,

> The emergence of new deterrence forces, based on new technology such as information, cyber-space, space, and new-material technologies, is revolutionarily changing the mechanism, method, and area of operation. *It heralds a completely new method of deterrence, symbolized by constructing [an] asymmetrical method of deterrence.* [Emphasis is mine.]

Again, the Chinese view deterrence as discouraging a rival from pursuing a proscribed course of action, as well as compelling a rival to take actions it would not otherwise pursue. This suggests that the CCP views nuclear forces not only as a means of precluding a nuclear attack on China, but as instruments of coercion as well. Like their US and Russian counterparts, the PLA appears to believe that precision-strike forces, and perhaps cyber weapons, can, under certain conditions, achieve levels of effectiveness comparable to those of nuclear weapons.

**Russian and Chinese Triad Modernization**
Although the United States has unilaterally foregone a major modernization of its nuclear deterrent in the thirty years since the Cold War, the same cannot be said of the two revisionist great powers or, for that matter, North Korea and Pakistan, with whom China has a long-standing relationship on nuclear matters.

**Russia’s Nuclear Force Modernization**
By one count, Russia has recapitalized over three-quarters of its strategic nuclear forces. As one senior US commander ob-
served, it’s easier to list the nuclear weapons and equipment Russia has not modernized, than to provide a comprehensive statement of its ongoing efforts, which stretch across all three legs of its triad.25

The land-based leg is the crown jewel of Russia’s nuclear triad. Moscow is currently replacing its Cold War era ICBMs with new missiles capable of carrying either single or multiple warheads. Upon its completion, which is anticipated shortly, Russia’s ICBM leg will comprise two missiles: the single-warhead SS-27 Mod 1 (Topol-M) and the SS-27 Mod 2 (Yars), with the latter capable of being armed with four multiple independently targetable reentry vehicle (MIRV) warheads. Russia is also developing a new heavy ICBM, the Sarmat (SS-X-30), which can be armed with ten or more warheads.26

Russia’s Strategic Naval Forces comprise six Delta-IV, one Delta-III, and three Borei-class submarines, each capable of carrying sixteen submarine-launched MIRVed ballistic missiles (SLBMs). Russia’s SSBN fleet has a combined maximum load of roughly 720 warheads but carries fewer, perhaps 560, to comply with limitations of the New Strategic Arms Reduction Treaty (START).27

Russia is estimated to have between sixty and seventy bombers, with perhaps fifty counting toward New START limits. Roughly 70 percent of these bombers are Tu-95MS Bears, capable of carrying up to sixteen nuclear-armed cruise missiles. The remaining bombers are Tu-160 Blackjacks, which can accommodate twelve nuclear-armed cruise missiles. Russia’s bombers can also carry nuclear gravity bombs. There are plans to field an upgraded, stealthier version of the Tu-160, known as Tu-160M2. As a whole, the bomber fleet could be armed with 700 or so nuclear cruise missiles, but estimates place the actual number at less than 600.28

Russia also has roughly 2,000 non-strategic systems outside New START limits that are capable of delivering nuclear warheads over shorter ranges. The US intelligence community anticipates that this force “is likely to grow significantly over the next decade.”29

China’s Nuclear Force Modernization
Current estimates of China’s operational nuclear warhead stockpile peg it at between 200 and 300 weapons.30 These estimates are crude, in large part because China is not a party to arms control agreements and has not shared information regarding its nuclear weapons industrial complex and forces.31 Shrouded behind this lack of transparency, China is improving its strategic nuclear forces on a pace that would enable it to double its nuclear weapons stockpile by 2030, consistent with Chinese President Xi Jinping’s directive to “strengthen strategic forces” and “accelerate the creation of high-level strategic deterrence.”32

Similar to Russia’s ongoing triad modernization effort, China’s program calls for fielding systems with MIRVs, maneuverable reentry vehicles, various deception measures, and hypersonic glide vehicles.33 China’s land-based leg currently comprises roughly 100 ICBMs, including the silo-based CSS-4 Mod 2 (DF-5A) and Mod 3 (DF-5B); the solid-fueled, road-mobile CSS-10-class (DF-31, DF-31A, and DF-31AG); and the more limited range CSS-3 (DF-4). China may also be developing a DF-5C and DF-31B ICBM, while fielding the DF-41 (CSS-X-20) ICBM, reportedly capable of carrying ten MIRVed warheads.34

The PLA has constructed six Jin class SSBNs, each capable of carrying up to twelve CSS-N-14 (JL-2) SLBMs. China’s H-6N long-range strategic bomber was publicly revealed in 2019 at the CCP’s parade celebrating the regime’s seventieth anniversary. The bomber can be armed with a nuclear-armed air-launched ballistic missile. The PLA also has a stealth bomber under development that will likely be fielded around the same time the US triad modernization program is currently scheduled to be completed.35
Summary

Both Russia and China view their nuclear forces’ purpose in some significantly different ways than has the United States. Russia has declared its willingness to employ nuclear weapons in a conventional conflict and to do so relatively aggressively, at least by contemporary US standards. The Chinese hope to leverage their nuclear deterrent not only to deter nuclear use against them, but also as a tool of coercion. Both of these revisionist powers are moving forward with programs to modernize all legs of their nuclear triad, with several new systems already deployed and more on the way. Of particular note is the two powers’ development of “heavy” ICBMs capable of carrying ten or more independently targetable warheads. Meanwhile, the United States is still debating how, and in some cases whether, to proceed with its modernization effort. If there is an ongoing nuclear arms race, the United States has been left standing at the starting gate.
The Defense Department cannot further defer recapitalizing Cold-War era systems if we are to maintain a safe, secure, and effective nuclear force that will continue to deter potential adversaries that are making improvements in their air defenses and their own nuclear weapons systems. The choice is not between replacing these platforms or keeping them, but rather between replacing them and losing them altogether. The latter outcome would, unfortunately, result in lost confidence in our ability to deter. The United States cannot afford this in today’s security environment or in any reasonably foreseeable future security environment.  

—Ash Carter, Secretary of Defense, 2017 Obama Administration

III. US TRIAD MODERNIZATION

The US triad that emerged in the 1950s and 1960s was the product of organizational rivalries, technological advances, and strategic thought. Its three legs have endured for over half a century, in no small part due to each leg’s unique advantages and the fact that each leg’s weaknesses are offset by capabilities resident in one or both of the other two.

Given their objective to overturn the existing US-led international order, both China and Russia are modernizing and expanding their nuclear forces to shift the nuclear balance in their favor. The Defense Department is pursuing its modernization program with an eye to preserving the favorable, stable nuclear balance that the United States has enjoyed since the dawn of the nuclear age. The program calls for replacing aging systems with comparable or fewer numbers of new systems, including 400 ICBMs, known currently as the Ground-Based Strategic Deterrent (GBSD); twelve Columbia-class SSBNs; and 100 or more B-21A stealth bombers.

The US modernization effort trails those of both China and Russia, and by a considerable margin. Indeed, even if the program is fully funded and proceeds on schedule, new systems will not begin to enter the force in significant numbers for nearly a decade. If the United States fails to move forward and delays or even cancels some or all of these programs, it will confront two

fully modernized Chinese and Russian triads. At that point, it
could easily take a decade or more to recover, with all that im-
plies for perceptions of the nuclear balance and deterrence.37

The last US strategic deterrent modernization efforts generated
considerable debate, and the current program is no exception.
The critics’ principal concerns center on the program’s cost, its
effectiveness as a deterrent, and its effect on crisis stability. This
chapter summarizes and assesses the critics’ arguments.

Those who challenge the program assert that the country’s se-
curity can be better assured with a smaller force and at a more
modest cost. For example, a group of distinguished US security
experts, including a former secretary of state, two former de-
fense secretaries, three former national security advisors, and a
former chairman of the Joint Chiefs of Staff declared that “de-
terring nuclear attack by today’s Russia (and by China for the
foreseeable future) can be achieved at significantly lower [nucle-
ar force] levels than are now planned” and that “an operationally
deployed force of fewer than 1,000 nuclear weapons may well
be justified.”38

Many in the arms control community have joined them in argu-
ing for similar or greater reductions in the US nuclear arsenal.39
One group, Global Zero, established a Nuclear Policy Commis-
sion that includes former secretary of defense Chuck Hagel and
the former vice chairman of the Joint Chiefs of Staff, General
(Ret.) James Cartwright. They presented a plan calling for the
United States to reduce its nuclear arsenal to a maximum of
900 weapons, in coordination with Russia but, if need be, uni-
laterally.40 The authors asserted that such reductions were war-
ranted since “security is mainly a state of mind, not a physical
condition.” Therefore, while “there remains a physical technical
side of MAD [mutual assured destruction] in our relations [with
Russia], it is increasingly peripheral” since “there is no conceiv-
able situation in the contemporary world in which it would be
in either country’s national security interest to initiate a nuclear
attack against the other side.”41 Yet, as was elaborated upon
above, Russian policy and military doctrine does not rule out
initiating nuclear weapons’ use. As China’s expansive view of
deterrence holds, forces whose purpose is to deter can also be
employed to coerce. Moreover, both Beijing and Moscow view
the current situation as requiring them to increase their nuclear
arsenal, or at least sustain it at its current level.

With respect to the US triad modernization program, some ar-
gue that deterrence would be enhanced by adapting US nucle-
ar forces to preclude them from being able to attack opposing
nuclear forces, or what are known as counter-force attacks.
Such actions would, one advocate asserts, require only a mod-
est nuclear force—five SSBNs and forty bombers—capable of
surviving an enemy attack. Such a force would, this argument
holds, “ensure nuclear deterrence vis-a-vis Russia, China, and
North Korea while… [reducing] the US stockpile of operationally
deployed weapons by two-thirds to 650.”42

Yet existing US missiles are accurate enough to hold at risk
even hardened enemy nuclear forces. It’s not clear how the US
military could “unring the bell” in the eyes of their nuclear rivals.
Moreover, such a “dumbing down” of US nuclear forces would
foreclose important options. For example, a longstanding con-
cern centers on a contingency where an enemy attacks only
America’s nuclear forces. Deterring this kind of attack could
be enhanced if the US military could respond in kind. Absent
such an option, following an enemy counterforce attack, the
only options left to the president would be to retaliate against
an enemy’s population and economy—or do nothing. Simply
put, removing the option to respond in kind would leave the US
vulnerable to nuclear coercion.

With regard to reducing the US deterrent to five SSBNs and forty
bombers with a total of 650 weapons, it’s difficult to see how this
would enhance deterrence. Such a force, which is now concentrat-
ed at five bases, could be attacked—perhaps with precision con-
vventional weapons—producing relatively little collateral damage.
The president would be left with a force of perhaps 200 weapons
located on a couple of SSBNs. As with the contingency described above, the commander-in-chief would confront the same options of attacking the enemy’s population and economy and triggering a similar attack against the United States, or of doing nothing.

Perhaps most importantly, by virtue of their actions, neither the Chinese nor the Russians see the virtue of adopting this kind of strategic posture. Since doing so is clearly within their means, it seems reasonable to assume they reject the view that a minimalist posture will enhance their security or deterrence.

The Land-Based Deterrent

The United States has 400 Minuteman III ICBMs deployed in 400 underground silos located in North Dakota, Montana, Wyoming, Colorado, and Nebraska. The plan calls for the Minutemen to be replaced by missiles comprising the GBSD beginning in 2028, with the new force being fully operational in 2036. The plan also provides for upgrading the 450 silos currently in use and related infrastructure. The Air Force plans to augment the force by installing all new nuclear command, control, and communications (NC3) systems. The GBSD missiles are designed to last sixty years. Toward that end, they have an “open architecture” to enable upgrades as needed. The missiles are also designed with capabilities to enhance their effectiveness “against modern, precision-guided missile defenses.”

Critics of the GBSD generally advocate extending the life of the existing Minuteman III missiles or, better still, eliminating the ground-based force entirely, abandoning the triad in favor of a “dyad” of SSBNs and bombers. Their position centers primarily on issues relating to crisis stability and cost.

With respect to stability, concerns have been raised that the land-based deterrent is vulnerable because its missiles’ location, unlike that of the triad’s submarines and bombers, is fixed. This means, they argue, that in the event of an attack, these missiles must be launched on extremely short notice before incoming enemy missiles can destroy them. Doing so, they assert, requires that GBSD missiles be placed on a hair-trigger alert, undermining crisis stability by increasing the risk that some missiles may be launched accidentally or prematurely before the attack’s true nature can be determined. To their point, during the Cold War both Soviet Russia and the United States experienced false alarms that could have led to a decision to retaliate against a perceived first strike. Critics also note that a long-standing unique advantage of the land-based deterrent—the ICBMs’ accuracy—no longer exists, as the Trident II missiles carried aboard SSBNs have warheads whose yield and accuracy match those of the current ICBM force.

Finally, GBSD program critics point out that the land-based missiles’ fixed location, limited maneuverability while in flight, range limitations, and polar route requires them to overfly Russian territory to reach targets in China or North Korea. This risks Moscow interpreting the American missiles as an attack on Russia. This risk, however, is acknowledged by US planners who assign forces in the triad’s other two legs to address targeting requirements for China and North Korea.

Critics of the GBSD also cite the program’s estimated $264 billion lifetime cost, arguing that it is excessive. If need be, they argue, the United States could extend the Minuteman III force, which they believe is feasible—if the force is reduced in size. If circumstances changed for the worse, some critics would support an option where the United States would reconsider procuring the GBSD.

What are we to make of these arguments?

The US land-based ICBMs, each armed with one warhead, are indeed fixed in location. This force also, however, enjoys the greatest geographic dispersion of the three triad components, extending as it does over five Midwestern states. Consequently, the land-based deterrent alone does not suffer from the “many nuclear eggs in a few baskets” vulnerability that characterizes the triad’s airborne and sea-based legs, which are currently
based at three airfields and two naval bases, respectively. Absent the land-based deterrent, these five bases—and the bulk of the US nuclear arsenal—could be destroyed at the cost of a handful of nuclear weapons—or perhaps by conventional precision fires, such as by hypersonic cruise missiles or hypersonic boost glide vehicles.

At present, however, an enemy must account for 400 Minuteman III missiles possessing over 25 percent of the US strategic nuclear arsenal. Even critics of the land-based leg concede that an enemy would have to allocate several nuclear weapons to take out each Minuteman III missile, each of which are armed with a single warhead. In military terminology, this puts the United States on the favorable end of a cost-exchange ratio of 2:1—or likely better. (See Appendix A.) Thus, the cost to an enemy seeking to eliminate the US land-based leg would be 800 (or more) weapons, or over half the operational weapons permitted by the New START agreement.

The potential exists to drive this exchange ratio even further to the United States’ advantage through the use of a “preferential” missile defense. For example, assume 100 US missile interceptors are deployed to defend the 400 GBSD ICBMs. If an attacker could not know in advance which 100 of the 400 GBSD missiles the interceptors were directed to defend, its problem is further complicated. To have a high confidence of success against the land-based triad leg supplemented by a missile defense shield, the attacker would have to add a third warhead to account for the possibility that an interceptor missile could take out one of the two warheads in the original attack plan. The tradeoff is now 3:1, with 1,200 warheads—roughly 80 percent of the New START limit—required to defeat the GBSD, making such an attack even more unattractive, thereby fortifying deterrence. Revealingly, during his tenure as defense secretary, James Mattis stated an enemy would have to commit as many as four warheads to be highly confident of destroying a Minuteman missile in its silo.

Then there are the critics’ concerns that the GBSD missiles might need to be placed on a hair-trigger alert to be launched before enemy missiles arrive. They fear that maintaining the ICBM force on high alert, even if only during a crisis, poses an unacceptably high risk of unauthorized or accidental US launch. The GBSD modernization, by including an upgrade to the forces’ command-and-control systems to include safeguards against cyber intrusions, is designed to address this risk. Moreover, it’s far from self-evident that the land-based deterrent must be placed on a hair-trigger alert. The land-based leg’s ability to drive up the cost of an enemy attack to prohibitive levels alone constitutes a major advantage, even if the US ICBM force never launches a single missile following an attack. Simply stated, the land-based missile force’s principal value is in deterring an enemy from launching its missiles, rather than in launching its own in a nuclear war.

In brief, the triad’s land-based leg offers significant advantages with respect to crisis stability. By absorbing a disproportionately large part of an attacker’s nuclear forces, it reduces an enemy’s incentive to attack. The GBSD, deployed as planned, serves as a kind of “missile sink,” draining an enemy’s nuclear forces. The force’s disposition, in 400 silos spread over five states rather than concentrated at five bases, as is the case with the triad’s sea and airborne legs, ensures that an enemy cannot hope to eliminate the great majority of the US deterrent by employing a handful of weapons. Moreover, the question must be asked: If land-based missile forces no longer have any strategic rationale to support them, why are the Chinese and Russians modernizing these forces? Why does their land-based leg remain primus inter pares in their triads? Perhaps most worrisome, why are they developing ICBMs capable of being fitted with up to ten warheads or more? If anything, both US rivals appear to be doubling down on their triad’s land-based leg. Those US policy-makers who assume that Chinese and Russian policy-makers’ views on deterrence mirror their own need to take these major anomalies into account.
Finally, what about the GBSD’s price tag, estimated at $264 billion?53 (See Appendix B.) It’s been argued that despite its deterrent value, the Defense Department’s resources are limited, and priorities must be set. But there is more to the story. First, the program’s cost will be spread over the program’s fifty-plus-year life cycle, which averages out to $5.28 billion a year, or less than 1 percent of the defense budget. Moreover, the triad’s land-based leg is the least expensive to maintain and has the highest level of steady state readiness.54 The most important factor, however, is that by serving as a missile sink against enemy weapons, the land-based deterrent imposes disproportionate costs on an enemy attempting to build a force to threaten this leg of the triad. Simply put, when it comes to cost, the advantage lies with the land-based leg of the triad.

With respect to extending the life of the current Minuteman III force and canceling GBSD, both the Obama administration’s Office of Science and Technology Policy and the Air Force concluded that this option would cost virtually the same or more as building the new ICBM, with the country left with an aging missile system as opposed to a new one.55 As Admiral Richard points out, it’s not even clear a life extension is practicable at any reasonable cost:

> It is getting past the point of “it’s not cost-effective” to life extend Minuteman III. You’re quickly getting to the point you can’t do it at all. That [missile] is so old that in some cases, the schematic drawings don’t exist anymore, or where we do have drawings, they’re like six generations behind the industry standard.”56

Nor would patching over the current Minuteman III missiles fix the land-based deterrent’s dated command, control, and communications (C3) systems. As Admiral Richard testified, “We will replace a 60-year-old [system], basically a circuit switch system with a modern... command and control system. So to pace the cyber threat alone, GBSD is a necessary step forward. But it is also far more flexible and resilient against any number of other threats that are presented.”57

The only way to realize significant savings would be to eliminate the land-based leg of the triad and move to a dyad of submarines and bombers. Yet this would likely yield greater savings for America’s rivals while undermining crisis stability: a classic example of pursuing a penny-wise and pound-foolish policy.

### The Sea-Based Deterrent

The US modernization plan calls for replacing fourteen Ohio-class SSBNs with at least twelve Columbia-class boats beginning in 2031. The Ohio-class boats have already been extended to an unprecedented forty-two years (no individual US Navy submarine has been in service longer than thirty-seven years) and will begin retiring from service in six years. The Columbia-class SSBNs will each have sixteen launch tubes, eight fewer than their Ohio-class predecessors. The twelve boats represent the absolute minimum needed to meet the requirement of maintaining ten operational boats—but only if they require substantially less maintenance than their Ohio-class predecessors.58

Relative to the land-based and airborne legs of the triad, the US SSBN fleet enjoys the strongest support among critics of the modernization program. The debate centers primarily on how robust this leg should be, and whether it can readily substitute for the advantages provided by the land-based leg, thereby rendering the latter superfluous and enabling the US military to downsize to a dyad.

As described above, some argue that the United States could reduce the size of its SLBM force even further than the twelve Columbia SSBNs currently in the program, down to ten or even five boats. Operational requirements could be met, they assert, by simply placing more nuclear “eggs” in fewer submarine “baskets”—by adding more warheads to the Trident II missiles aboard fewer submarines.59 A force of five Columbia
SSBNs, it’s been asserted, could support a minimum deterrence strategy, assuming that roughly 15 percent of a much smaller target set is covered by US conventional forces. This approach, which includes abandoning the land-based leg of the triad, finds a radically truncated US seaborne deterrent hosting by far the largest share of weapons in a nuclear arsenal far below the New START limits. The shortcomings associated with this course of action are manifest, as addressed earlier in this assessment’s discussion on proposals to radically reduce the US strategic deterrent. They wholly discount the fact that the Navy requires four SSBNs to keep one at sea on patrol, while ignoring the potential for collision, grounding, fire, or other perils that can put a ship out of commission for an extended period.

Of note, as one critic admits, the seaborne deterrent’s effectiveness depends on a “resilient C3 network” that must support a force operating underwater deployed thousands of miles from its base. Then there is the matter of sustaining the sea-based leg’s stealth, and of making good on promises with respect to reduced maintenance requirements. Even one of the modernization plan’s critics, while advocating deep reductions in the US nuclear arsenal, cautions that the risk due to breakthroughs in an adversary’s ability to detect and sink US strategic submarines or due to a systemic technical problem—such as a propulsion reactor flaw or defective warheads—requiring urgent correction cannot be categorically ruled out. That is especially true over the 42-year lifetime of the replacement boats. In this dire circumstance, 40 heavy bombers armed with at least 450 nuclear warheads would be placed on 10-minute runway alert.

A submarine’s defense is almost entirely reliant on its ability to avoid detection—its stealth. But there is no guarantee that US SSBNs will remain immune from detection over the next half century. Given the rapid ongoing advances in artificial intelligence, data processing, and sensors, moving to a dyad dominated by SSBNs involves betting nearly all of America’s nuclear chips on sustaining this advantage over the next half century. Considering the prospective risk to US national security should advances in underwater detection continue, such a bet would give even a riverboat gambler pause. Nor can those calling for reducing the number of submarines in the program guarantee that they will meet the expectations regarding requiring substantially less maintenance than the Ohio SSBNs.

The critic’s solution to this problem—placing forty bombers on high runway (or “strip”) alert, seems fanciful. First, it assumes that US bombers—which currently are not on day-to-day nuclear alert, could quickly be placed on alert once the SSBN problem is identified. Second, it assumes that once these bombers are placed on strip alert, they can maintain this ten-minute alert indefinitely. Third, assuming such a bomber force could get aloft in less than ten minutes, it assumes it could penetrate fully alerted enemy air defenses in sufficient numbers to accomplish their mission. Moreover, each bomber would have to continue avoiding these defenses while moving, Santa Claus-like, to its various targets.

The risk due to breakthroughs in an adversary’s ability to detect and sink US strategic submarines or due to a systemic technical problem—such as a propulsion reactor flaw or defective warheads—requiring urgent correction cannot be categorically ruled out. That is especially true over the 42-year lifetime of the replacement boats. In this dire circumstance, 40 heavy bombers armed with at least 450 nuclear warheads would be placed on 10-minute runway alert.

As noted above, some critics of the GBSD modernization effort cite concerns over the reliability of its command-and-control system. Oddly enough, they seem relatively sanguine regarding the US national command authority’s ability to communicate commands to submersed submarines thousands of miles away at sea, and to do so reliably for the next half century.

Finally, some critics, in an effort to cut costs, while citing their support for a truncated Columbia-class, also advocate delaying constructing the first two boats. This is almost certain to result in another penny-wise and pound-foolish example of defense procurement. Given what they have been told by the Defense Department, the defense industrial base firms responsible for constructing the Columbia class are investing in the equipment
and the training of a skilled workforce to execute the modernization plan. This effort cannot be stopped and started on a whim without incurring substantial costs. The same can be said with respect to the other major components of the US modernization program.

The Airborne Deterrent

The airborne leg of the triad is positioned at three main bases in the United States. The nation’s bomber force comprises forty-six B-52H and twenty B-2A nuclear-tasked bombers. Each B-52H can carry up to twenty single-warhead air-launched cruise missiles with yields ranging from 5 to 150 kilotons. The B-2A is equipped to drop high-yield (1.2 megaton) B83 gravity bombs and variable-yield (0.3 kilotons to 150 kilotons) B61 gravity bombs.

The triad modernization program envisions an updated bomber fleet of at least 100 B-21 stealth bombers, with some calling for as many as double that number. This aircraft, now in development, is expected to be operational by the end of this decade. The Defense Department plans to retire all its B-2 bombers by 2032, and all B-1 bombers by 2036.

Of note, only twenty-one of the originally planned 132 B-2 bombers were procured, raising concerns over whether the B-21 might suffer the same fate. There are, however, major differences between the two programs. Perhaps most important, the B-2s were viewed, not as replacements for current bombers, but as boosting the existing fleet’s capabilities. This made it easier to reduce the B-2 buy, since any number of these bombers would leave the existing bomber force more capable than before. The other major difference, of course, is found in the threat to US security. When the B-2 was being fielded in the early 1990s, the Soviet Union was collapsing, greatly reducing the danger to the United States. Today the opposite is true, as America confronts two hostile great powers.

Moreover, advanced Chinese and Russian air defenses find the B-52’s ability to penetrate enemy airspace highly suspect. For this reason, the B-52s are equipped with air-launched cruise missiles (ALCMs). But those missiles are decades old, increasingly difficult to maintain, and, like the B-52s, progressively more vulnerable to advanced air defenses. Simply put, cruise missiles are similar to aircraft and, like aircraft, require some kind of penetration aids (such as speed or stealth) to avoid sophisticated enemy integrated air defense systems. Consequently, a Long-Range Standoff (LRSO) cruise missile is being developed with an eye to extending the B-52 bomber’s effectiveness. The LRSO is also being touted as providing the B-21 with a hedge capability should an unanticipated breakthrough in enemy air defense effectiveness emerge during the bombers’ service life, which, history suggests, could run forty years or more. Owing to its substantial range, the LRSO will enable a single bomber to cover targets over larger geographic areas than if it carried only gravity bombs, thereby reducing the need for additional B-21 bombers and aerial tanker aircraft. Alternatively, arming B-21s with LRSOs will significantly enhance their ability to hold targets even deep within China and Russia at risk. Here, once again, the US military is playing catch-up, as both China and Russia are deploying new nuclear ALCMs.

As with the triad’s land-based leg, the US bomber force has also been effective at imposing disproportionate costs on rival militaries. During the Cold War, for example, the Pentagon’s Office of Net Assessment pointed out the advantages of maintaining the triad’s airborne leg, citing the enormous cost advantage that accrued to the United States. In fact, when Herbert York reviewed the Cold War competition between US bombers and Soviet air defenses in 1986, he calculated that while the US bomber force had cost about $50 billion, the Soviets had spent around ten times as much on air defenses, while never achieving the ability to defeat a US air attack. York concluded that the Soviet air defense program was a “hideously expensive failure.” Moreover, the US bomber fleet has proven its worth in every significant military operation since World War II.
Regimes like those of the Soviet Communists and the CCP that seek to impose a totalitarian system of control over their people accord high priority to controlling their borders and airspace. China boasts the longest border of any country, at roughly 13,500 miles. Given the CCP’s proclivities, the PLA is tasked with providing integrated air defense systems to cover China’s long borders. This argues for the US military to emphasize maintaining and enhancing its bomber force’s ability to penetrate China’s airspace. As the Cold War competition with Soviet Russia showed, this competition between air defenses and air strike forces favors the latter by as much as an order of magnitude. In brief, the CCP will be faced with having many of its key assets being held at risk by American forces operating in the air domain, or attempting to defend against them at a highly disproportionate cost.

Finally, it must be noted that the modernization program of the deterrent’s airborne leg is quite different from those of the land- and sea-based legs in that the bomber fleet can be—and consistently has been—used for conventional missions. At the program’s inception, the issue of whether to even make the B-21 capable of delivering nuclear weapons was debated. The choice was an easy one, as the Defense Department’s analysis concluded the nuclear-related costs for the B-21 program were a very modest 5 percent.76

Nuclear Command, Control, and Communications

Today’s NC3 network was last comprehensively updated some three decades ago, although some elements date back to the late 1950s.77 There is widespread agreement that any effort to modernize the triad must strengthen NC3 survivability and reliability.78 If a prospective attacker’s decision-makers believe the effectiveness of a rival’s early warning, and NC3 systems are significantly compromised, this would logically reduce the anticipated costs (and risks) of executing a surprise attack during a crisis, all other factors being equal. If so, deterrence could be at risk.

The US triad’s NC3 systems are being challenged in multiple ways. Both China and Russia have, and continue to develop and field, antisatellite capabilities to threaten US space-based early warning systems, including those used to transmit emergency action messages used in executing nuclear war plans.79 The introduction of cyber weapons further complicates the picture. Cyber payloads appear to have the potential to disable or corrupt early warning and command-and-control systems.80 Insofar as cyberweapons reduce senior decision-makers’ confidence in their early warning and NC3 systems, they may be compelled to delegate nuclear (or strategic) release authority to subordinate commanders, substantially increasing the number of individuals who can authorize an attack. If at least one of these individuals is more risk tolerant than the senior decision-maker(s), deterrence will be weakened.

Nor can the NC3 system be assumed to be bug free. This is primarily due to negligence in the design, manufacture, and installation of many of its components, which were often purchased off-the-shelf and from foreign suppliers. Apparently, some components have been found to be contaminated.81

The triad modernization program calls for modernizing the NC3 system along several lines of effort. One focuses on modernizing the NC3’s core capabilities. This is supported by demonstrations, experiments, and tests aimed at identifying systemic weaknesses as well as opportunities to enhance existing NC3 programs and operations. The effort will be supported by technology enablers, including artificial intelligence, digital engineering, and modeling and simulation. The program gives priority to improving the US NC3 posture in space, enhancing the system’s resistance to emerging cyber and cryptographic threats, replacing outdated legacy systems, and increasing NC3 resilience through an open (rapidly reconfigurable) architecture.82

Summary

The US triad that emerged in the 1950s and 1960s has endured primarily because each leg possesses unique advantages that
also serve to offset weaknesses in one or both of the other legs. Today’s triad is well beyond its projected life expectancy, yet the US modernization effort trails those of China and Russia, and by a considerable margin. Even if the program is fully funded and proceeds on schedule, new systems will not begin to enter the force in significant numbers for nearly a decade.

The program has its critics, whose principal concerns center on the program’s cost, its effectiveness as a deterrent, and its effect on crisis stability. Many GBSD critics advocate eliminating the land-based triad leg, abandoning the triad in favor of a dyad of SSBNs and bombers. Their position centers primarily on issues relating to crisis stability and cost.

Their argument is unpersuasive. While the land-based missile force is highly dispersed, the sea-based and airborne legs are highly concentrated at five bases, which could be destroyed—along with most of a US dyad arsenal—at the cost of a handful of nuclear weapons. The opposite is true for the land-based deterrent. An enemy would have to allocate several nuclear weapons to take out each missile and its single warhead. This puts the United States on the favorable end of a cost-exchange ratio of 2:1, or likely better. As for its own cost, the GBSD program cost averages out to $5.28 billion a year, less than 1 percent of the defense budget.

The critics’ assertion that the GBSD missiles must be placed on a hair-trigger alert to be launched before enemy missiles arrive misses the point. The land-based leg’s ability to drive up the cost of an enemy attack to prohibitive levels alone constitutes a major advantage. In brief, the land-based missile force’s principal value is in deterring an enemy from launching its missiles, rather than in launching its own in a nuclear war.

A dyad centered on the sea-based leg would incur its own risks, as there is no guarantee that US SSBNs will remain immune from detection—their only defense—over the next half century. It’s imprudent to bet nearly all of America’s nuclear chips on sustaining this advantage indefinitely. While SSBN modernization is generally supported, the current program of twelve boats represents the absolute minimum required—and even then only if they require substantially less maintenance than their Ohio-class predecessors.

As with the triad’s land-based leg, the US bomber force has long proven effective at imposing disproportionate costs on rival militaries. The bombers remain the only triad leg that can be recalled after being launched.83 It’s also the only component of the three that is dual use, having proven its worth in every significant military operation since World War II.

Today’s NC3 network was last comprehensively updated some three decades ago, with some elements dating back to the late 1950s. There is widespread agreement that NC3 survivability and reliability must be strengthened, and this has been “baked” into the triad modernization program.
The cornerstone of our strategic policy continues to be able to deter deliberate nuclear attack upon the United States or its allies. We do this by maintaining a highly reliable ability to inflict unacceptable damage upon any single aggressor or combination of aggressors at any time during the course of a strategic nuclear exchange, even after absorbing a surprise first strike.84 [Emphasis added.]

—Robert McNamara
Secretary of Defense
Kennedy and Johnson Administrations

Two superpowers, Soviet Russia and the United States, dominated the Cold War nuclear competition. The other nuclear powers—China, France, Great Britain, and Israel—had nuclear arsenals that constituted, even collectively, only a tiny fraction of the superpowers’ individual forces.85 Today, however, the United States and Russia have much smaller nuclear arsenals, as called for in the New START, which limits each country to 1,550 operational (or deployed) strategic nuclear weapons. The treaty was recently extended for another five years, and the US nuclear modernization program is designed with the treaty’s limits in mind. Absent a disruptive shift in the competitive environment, it’s plausible that Russia and the United States could continue abiding by the treaty indefinitely.

But is the current nuclear competition likely to remain frozen in time?

Photo: The DF-41 intercontinental ballistic missile is seen during a military parade to celebrate the 70th Anniversary of the founding of the People’s Republic of China at Tiananmen Square on October 1, 2019 in Beijing, China. (The Asahi Shimbun via Getty Images)
Today’s strategic rivalry is quite different from that of the Cold War era, or from the so-called Second Nuclear Age, characterized by the “nuclearization” of Asia (in the form of India, North Korea, and Pakistan), and the threat of nuclear terrorism. Current trends strongly suggest that the nuclear competition’s characteristics are highly unlikely to remain static, or to evolve serendipitously in ways favorable to the United States. Indeed, it appears a Third Nuclear Age will soon be at hand, carrying with it much of the baggage of the second while witnessing the emergence of a tripolar (or multipolar) and multidimensional strategic forces competition.

The nuclear competition could experience a disruptive change in four ways that would threaten US vital interests: the emergence of a tripolar great nuclear power rivalry; the prospect of nuclear breakout; the appearance of significant second-tier nuclear powers; and the rise of a multidimensional strategic rivalry supplanting the nuclear competition. These are elaborated upon below and include a discussion of their implications for deterrence and US triad modernization. While there are no guarantees that any of these shifts will occur, the odds of at least two of these futures coming to pass is highly likely; indeed, one—a multidimensional competition—is generally conceded to have arrived. Thus, any thorough assessment of the US nuclear modernization program must take these new aspects of the competition into account.

We begin, however, with a review of the New START agreement. While designed in part to freeze the nuclear status quo, the treaty ironically increases the incentives to move the competition to a Third Nuclear Age.

**New START**

Among its first foreign policy initiatives, the Biden administration extended the New START agreement with Russia for an additional five years. In so doing, the administration sought to extend the rough parity that exists between the two countries’ nuclear forces. Maintaining parity has been an important consideration for both Washington and Moscow in their arms control agreements over the last half century, beginning with the first Strategic Arms Limitation Treaty (SALT) signed in 1972.

Parity is important for military and political purposes. First, all other factors being equal, nuclear parity, defined as both sides having roughly the same force levels, arguably enhances mutual assured destruction and, by extension, deterrence and stability, as each “scorpion” can attempt to eliminate its rival only by accepting grave risk to its own survival. Second, parity helps enhance the perception that neither side is inferior to the other. Sustaining parity is especially important to the United States, which is committed not only to deterring and responding to attacks upon itself, but to extending deterrence to cover threats of nuclear coercion or attacks against its allies and partners. Thus, to the extent New START preserves parity between Russia and the United States, it can be said to enhance deterrence by enabling both sides to field forces that provide them with an assured destruction capability whose arsenals are second to none.

New START, however, is not comprehensive. The treaty fails to capture all nuclear weapons in the two powers’ arsenals. Russia has as many or more theater or tactical nuclear weapons (roughly 4,400) than it does strategic weapons limited by New START, as does the United States, which retains around 3,800. Thus, by one metric, New START encompasses less than half of the two powers’ nuclear arsenals.

This is significant, as New START limits weapons, not launchers. Therefore, it’s possible that Moscow could rapidly increase its strategic nuclear forces by shifting nuclear weapons from short-range to long-range (strategic) delivery systems. This practice is known as breakout. Further complicating matters, Russia maintains enormous stocks of fissile material, along with the ability to produce hundreds of new warheads a year. This breakout capability, if exercised, could produce a rapid shift in the strategic balance as the United States’ production capacity remains effectively dormant.
Then there is the New START’s limit of 1,550 deployed weapons. This is a major achievement, given that the two powers’ arsenals were well over ten times greater at certain points in the Cold War. But as long as the 1,550 ceiling holds, it also establishes a radically lower barrier to entry for those states seeking to achieve great nuclear power status. Hence the concerns that New START may incentivize some states to join Russia and the United States in the club of great nuclear powers. China is clearly one such state. It has the motive and means to match the two Cold War nuclear powers’ arsenals. As will be elaborated upon shortly, by some estimates, China is already on a path toward achieving this objective.

With this in mind, the House Armed Services Committee chairman, Representative Adam Smith, reasoned that China should be part of any arms control discussions with Russia and the United States. In response, China declared it would be “happy” to participate in trilateral arms control negotiations—but only if the United States reduced its nuclear arsenal to China’s declared level. In fact, the CCP has persistently rejected efforts by the United States to join in negotiation on arms control. Indeed, the 2013 version of Science of Military Strategy states that any outside pressure (waibuyali) for China to participate in arms limitations or reductions while it remains greatly inferior to the United States and Russia in nuclear capabilities should be seen as a threat.

As arms control negotiations typically require the parties involved to share information regarding the forces under consideration, including their numbers and capabilities, one wonders: What are the Chinese trying to hide? It certainly cannot be their declared inferiority to US and Russian nuclear forces, which is purportedly known. If the CCP wants to incentivize Washington and Moscow to reduce their nuclear forces, why does it continue to raise suspicions through its lack of transparency on this issue?

China’s demand is unacceptable. By cutting its arsenal to the level of China’s self-declared arsenal of several hundred weapons, Washington effectively eliminates any barrier to nuclear great power status, creating a multipolar nuclear competition where even countries like North Korea could soon achieve parity with the United States.

The implications of such a reduced nuclear posture for extended deterrence are clear. Longstanding American allies, such as Japan and South Korea, would find Washington having to balance against the Chinese, Russian, and North Korean arsenals, and perhaps those of Pakistan and Iran as well. As will be discussed presently, Tokyo and Seoul, as well as leaders in other allied capitals, would no doubt wonder: What could be spared from the US arsenal to defend them when the Americans are faced with the prospect of maintaining an assured destruction capability against three or more comparably armed rivals?

Growing doubts on the US extended deterrence guarantee could find Seoul accommodating to Pyongyang and Tokyo refraining from supporting US and allied operations should war occur with China or North Korea. Moreover, the smaller the US arsenal size, the more vulnerable it is to cheating, a perennial feature of arms control agreements.

The Chinese appear to share these concerns over the ongoing modernization and expansion of nuclear forces and arsenals. The 2013 version of Science of Military Strategy notes that China confronts an increasingly “complex” nuclear environment in which it must account for the expanding or latent nuclear capabilities of India, as well as the United States and, prospectively, Russia. Just as important, China clearly has the means to address this expanding challenge. A Chinese military theorist, Major General Yao Yunzhu, captures the situation well in noting, “To keep the arsenal lean, China has to exercise restraint in developing nuclear weapons; to keep the arsenal effective, China has to modernize it to ensure credibility after a first nuclear strike.” Based on China’s ongoing nuclear modernization programs and its expanding arsenal, it’s clear that the latter priority has won out.
A Tripolar Nuclear Competition

By the time its planned triad modernization effort is completed in the mid-2030s, it seems highly likely the United States will confront a tripolar competition with China and Russia. The US military may also find that other rivals’ nuclear arsenals have expanded to the point where their growing influence on the nuclear balance could be ignored by US policy-makers only at America’s peril.

There is general agreement that Russia is likely to continue seeking nuclear parity, or a rough equivalency, with the United States. There is far less agreement over China’s nuclear potential or aspirations. Consequently, this section focuses primarily on the latter issue. This is followed by an assessment of the prospects for a class of second-tier nuclear powers emerging with emphasis on prospective US rivals.

China’s Nuclear Potential

What is the true size of China’s nuclear arsenal? And what could it be by the time the US nuclear deterrent modernization effort is scheduled to be completed? China appears to be on its way to doubling its nuclear arsenal by the end of this decade, and would appear to need to do little more than continuing to run on “program momentum” to match US and Russian levels in the 2030s while it completes a major upgrade to its nascent triad.

As noted above, owing to the CCP’s lack of transparency, open-source estimates of China’s nuclear arsenal are based primarily on accepting what Beijing declares it to be, and on estimates of China’s stock of fissile materials, which are also highly dependent on CCP declarations. In contrast to other nuclear weapon states, China has failed to provide official declarations about its production of highly enriched uranium (HEU) and plutonium for nuclear weapons. Nor has China publicly released information about its total fissile material stocks.

China’s current nuclear arsenal is estimated at roughly 200-300 weapons. While stockpiles of its fissionable material are estimated at around 16 metric tons (MT) of HEU, with 20 percent uncertainty. Thus, the true amount could be anywhere between 12 and 20 MT. China is estimated to have between 1.1 and 2.7 MT of plutonium. These estimates are highly dependent on the assumption that China ended HEU and plutonium production in 1987 and 1990, respectively.

China’s Nuclear Arsenal: A Great Leap of Faith?

How many nuclear weapons could China have if one assumed it is limited to these estimated fissile material stocks? Taking a great leap of faith that China has produced no fissile material over the last thirty-one years, the answer centers primarily on three factors: the amount of plutonium and/or HEU needed to fabricate a weapon, the weapon’s yield, and the weapon’s design.
Generally speaking, the higher the enrichment level, the less HEU is required to make a weapon. Similarly, the more sophisticated the design, the less fissile material needed. Assuming the design uses HEU, a simple gun-type design of the kind used in the “Little Boy” bomb dropped on Hiroshima would require 40–50 kilograms (kg) of HEU.103 An implosion weapon would require far less HEU, roughly 9–12 kg. For a simple plutonium implosion design of the type used in the attack on Nagasaki, roughly 6 kg would be required. A more sophisticated plutonium design would require only around 2–4 kg of plutonium.104

It seems reasonable to assume the Chinese possess and employ more sophisticated nuclear weapons designs than those used nearly eighty years ago. If so, using both the upper and lower range estimates for Chinese HEU and plutonium stocks, and the upper and lower estimates of the HEU and plutonium required for a given weapon design, an extremely rough estimate of the Chinese nuclear arsenal finds that China could have over 2,000 weapons—or as few as 400. The weapons count could be significantly lower if one assumes that the Chinese have built weapons of considerably greater yield than those described above.

The relationship also appears to be nonlinear in favor of increased yield. Put another way, more sophisticated designs than those used to estimate the Chinese nuclear arsenal are capable of generating a nuclear explosion at a given yield with even less fissile material.105

With regard to thermonuclear weapon designs,106 the same principles hold: that is, the yield is primarily a function of the quantity of fissile materials used and the weapon design.107 It is assumed that the average modern nuclear warhead contains the equivalent of about 25 kg of uranium enriched to 90 percent.108 If so, given the range of estimates of China’s HEU stocks, the CCP could have between 440 and 680 thermonuclear weapons. A recent estimate by RAND scholars reached a similar conclusion, finding that China’s nuclear arsenal could comprise as many as 575 weapons.109

There are reasons to question the low-end estimates, as they are based on unconfirmed assumptions that the Chinese ceased producing fissile material well over a quarter of a century ago. Yet if Chinese fissile material stocks are fixed, why does the US intelligence community believe that China’s nuclear arsenal will “at least double in size” as China expands and modernizes its nuclear forces?110

Why would China understate the size of its nuclear arsenal? Perhaps by continuing to claim that its arsenal is barely on the
level of Pakistan’s and may not even equal North Korea’s by mid-decade, Beijing believes it can realize some propaganda value as the great power that is exercising self-restraint when it comes to nuclear arms. This posture also enables the CCP to continue responding to US calls to enter into trilateral arms control discussions by expressing its willingness to do so—but only if Washington (and presumably Moscow) cut their arsenals to what Beijing claims is its level. From the CCP’s perspective, should this tactic succeed, it would not only reduce the threat from Russia and the United States, it would also make breakout (see below) easier.

Assuming that China intends to at least double its nuclear arsenal; and that it can do so despite having stopped producing fissile material during the Cold War; and that the CCP has no plans to restart production, Beijing would have to procure fissile material, with Pyongyang and Islamabad being the most likely sources. Both North Korea and Pakistan have been producing fissile material for over two decades and show no sign of stopping. Both countries also received Chinese assistance in developing their nuclear arsenals.111

North Korea
A recent RAND assessment finds the Hermit Kingdom could have nearly 250 weapons by 2027—an arsenal comparable to, or greater than, some contemporary estimates of China’s. The RAND analysis also relies on estimates of North Korea’s plutonium and HEU stocks, and assumes that North Korea is serious about expanding its arsenal; that it is generating fissile material from its nuclear reactors; and that this material is being used to fabricate nuclear weapons.

Using these data, and recent US intelligence open-source evaluations of North Korea’s arsenal, RAND finds that Pyongyang may currently have between 67 and 116 weapons.112 The study states, “As the number of North Korean nuclear weapons hits 100 or so, the North Korean leaders might perceive that they could make some of those weapons available for sale.”113 Assuming the country’s dictator, Kim Jong-Un does not require over 200 weapons by mid-decade, it’s plausible that he could ship excess fissile material to China in exchange for financial and material assistance for his weak economy.

Pakistan
Pakistan is believed to have roughly 165 nuclear weapons.114 It continues producing fissile material, both HEU and plutonium.115 China has built four nuclear power reactors in Pakistan and is constructing two more. According to some assessments, Pakistan is capable of producing 25–60 kg of plutonium

<table>
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<th>DESIGN</th>
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<th>LOW HEU STOCK NUMBER</th>
<th>HIGH PU STOCK NUMBER</th>
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Source: Author
annually. Recent estimates are that Islamabad has around 370 kg of plutonium and between 3.3 and 4.1 MT of HEU. Employing the same methodology used in calculating China’s arsenal, Pakistan’s arsenal could comprise between 62 and 93 plutonium weapons and 220–342 HEU weapons, for a total of between 282 and 435 weapons. If however, Pakistan’s arsenal entirely comprises thermonuclear weapons, the size shrinks to between 178 and 210. As with China and North Korea, absent a definitive accounting of Pakistan’s fissile stocks, design expertise, and weapons mix, it’s difficult to arrive at a high-confidence estimate.

If the current approximations of Islamabad’s arsenal and fissile stocks are correct, it possesses a significant surplus of bomb-making materials. Indeed, it’s been asserted that Pakistan simply lacks enough nuclear-capable launchers to accommodate the 200–300 or so warheads it is capable of fielding. As Pakistan continues producing fissile material, it would seem to serve two purposes: to enable an increase in the country’s arsenal, and as a commodity that, like any other, can be traded or sold. The former suggests Islamabad may be seriously considering becoming a second-tier nuclear power, while the latter argues that Pakistan, perpetually in need of financial assistance, may be looking for opportunities to monetize its fissile material assets. Of course, these options are not mutually exclusive.

A China-Russia Nuclear Axis?
Would Russia, with its enormous fissile material stocks, aid China? In testimony before the Senate Armed Services Committee, the head of US Strategic Command, Admiral Charles Richard, stated that Russia is pursuing a strategic partnership with China at the highest levels. He went on to declare, “Prudence dictates military planners consider and account for the complex threat environment, enabled by the strategic cooperation of these two nuclear-armed States.... For the first time in our history, the nation is on a trajectory to face two nuclear-capable, strategic peer adversaries at the same time.” That being said, it seems unlikely, given their past history, that Russia would provide fissile material to China.

Summary
Based on unverified estimates of China’s fissile stocks and what we know regarding the amount of fissile material required for certain weapons types, the PLA could have the size arsenal that is generally cited of roughly 200–300 weapons—or considerably more. China’s decades-long military buildup, which finds it competing with the US military in fielding a wide range of advanced capabilities, is now complemented by its ongoing nuclear modernization program, apparently coupled with plans to at least double its arsenal’s size. Given its concerns over the Russian,

<table>
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<th>DESIGN</th>
<th>FISSILE MATERIAL NEEDED</th>
<th>HIGH HEU STOCK</th>
<th>LOW HEU STOCK</th>
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Source: Author
US, and Indian nuclear arsenals; its vigorous efforts in all other significant areas of the military competition; and its position as the world's second-greatest economic power, it seems highly unlikely that China will be content standing in the shadows of Russia or the United States in the ultimate measure of military power.

Thoughts on a Tripolar Nuclear Competition

The radical reductions in US and Russian Cold War nuclear arsenals, combined with China's nuclear modernization and arsenal expansion program, are shifting the competitive environment from the bipolar Cold War framework toward what will likely be a tripolar system by the time the US triad modernization is completed. As China's buildup proceeds, US policy-makers will find it increasingly difficult to rely on arms control agreements like New START to ensure nuclear parity and crisis stability. In particular, New START does not preclude Russia from positioning itself to affect a breakout of the agreement. It does nothing at all to constrain China.

A “Big Three”?

In a world of three nuclear powers of the first rank with roughly comparable arsenals, each would have to contend with two rivals whose combined arsenals are twice the size of its own. Not surprisingly, such a disruptive shift in the strategic nuclear competition would find that some characteristics that contributed to crisis stability and deterrence during the bipolar US-Soviet Cold War nuclear competition would no longer exist. Parity—having a comparable nuclear capability with that of one's existing or prospective rival(s)—would no longer be an option for each of the three rivals. At the risk of stating the obvious, it's simply not possible for each of the three major nuclear powers to have an arsenal equal to the combined arsenals of the other two powers. Yet neither Russia nor the United States has felt secure with the other having a significant numerical advantage in strategic nuclear forces, as reflected in arms control agreements over the past half century. Absent parity, it would be more difficult to establish and sustain force postures that provide an assured dual second-strike capability.

In a tripolar nuclear competition, each of the three major powers would feel pressured to hedge against the possibility that its two rivals might form an alliance against it. After all, the current China-Russia axis supplanted the late Cold War era US-China informal partnership that was preceded by an earlier collaboration between Moscow and Beijing. The power threatened with isolation would be incentivized to increase its arsenal to offset, at least partially, the 1,550-weapon shortfall it confronts. This could trigger an arms race, as each major nuclear power hedges against the possible emergence of a new coalition of major and possibly second-tier nuclear powers as well.

One factor that may work in the United States’ favor is that since China and Russia share a common border, each must also account for each other’s shorter-range, or theater, nuclear forces. That being said, the United States also faces this threat, but within the context of extended deterrence. The implications of this positional asymmetry for the nuclear balance, deterrence, and crisis stability are unclear. Were Russia’s theater nuclear forces positioned in the Far East along China’s border, they could pose a clear threat to its industrial heartland. Russian theater nuclear forces capable of ranging America’s allies’ homelands in Europe and the Western Pacific could find Washington compelled to respond in kind, as it did during the Cold War following Soviet deployments of SS-20 theater missile systems.

Again, what does seem clear is that the Cold War era bipolar perspective on the nuclear competition is becoming progressively less relevant, while strategic arms control agreements like New START, modeled on Cold War era agreements, are in danger of becoming relics of a bygone age.

Breakout?

During the Cold War, a key characteristic of the nuclear competition between the two superpowers was the fear that one would attempt a breakout. As viewed from the US side, the term referred to the possibility that Moscow might be in a posi-
tion to rapidly boost its strategic forces, thereby breaking out of the arms control treaties limiting its forces.

At the core of these fears during the 1970s and early 1980s was the Soviet SS-20 intermediate-range ballistic missile (IRBM), a two-stage (shorter-range) version of the three-stage SS-16 ICBM. When the SS-20 was ready for deployment, the SS-16 was still being developed. Once the Soviets perfected the SS-16, however, they could stockpile its third stage and, should they decide, rapidly convert the SS-20s into ICBMs.

Consequently, a major US objective during the SALT II negotiations was reducing the danger of an SS-16 breakout. It was behind the long-sought ban on ICBM launchers that could be rapidly reloaded, and on the ban against storing excess missiles. Thus, the SALT II treaty limited strategic nuclear delivery vehicles—ICBMs, SLBMs, and bombers. Put another way, it focused on launchers, not warheads.

What has this to do with China?

First, similar to concerns with respect to Soviet missile developments during the Cold War, the CCP has long been building up its ballistic missile forces. Most of these missiles are short-range ballistic missiles. The PLA, however, boasts growing numbers of medium- and intermediate-range ballistic missiles (MRBMs and IRBMs, respectively).

Moreover, the new Chinese DF-41 ICBM is capable of carrying ten MIRVs. At least one Chinese nuclear strategist asserts that any PLA MIRVed missiles would have only one actual warhead, with the others being decoys. As with respect to China’s fissile material stockpiles, other countries are expected to take such declarations on faith. As noted above, China has several types of ballistic missiles in production, and there are no constraints on its ability to stockpile these missiles or to preclude it from exploring options to extend its IRBMs to intercontinental range. Apparently, no insurmountable technical barriers exist to preclude the PLA from rearming its current inventory of conventionally armed ballistic missiles with nuclear payloads. The recent revelations that the PLA is constructing over 200 ballistic missile silos only serves to heighten concerns regarding the CCP’s intentions.

It appears the CCP will have, through accident or design, the option of vastly increasing the size of its strategic nuclear arsenal, and doing so on relatively short notice. Given the absence of constraints on China’s missile forces, combined with the lack of CCP transparency with respect to its fissile material stocks, US policy-makers would be foolish to discount the possibility of a Chinese breakout.

Why would China seek to break out? Why not simply gradually build up its nuclear forces to match the US and Russian arsenals? China may, of course, follow this path, moving gradually toward its objective. But breakout has its advantages. For one, while positioning itself for breakout, the CCP can also continue claiming that its arsenal is barely on the level of Pakistan’s and may not even equal North Korea’s by mid-decade. Thus Beijing gains propaganda value as the great power that is exercising self-restraint when it comes to nuclear arms. This posture also enables the CCP to continue responding to US calls to enter trilateral arms control discussions by expressing its willingness to do so—but only if Washington cuts its arsenal to what Beijing claims is its level. From the CCP’s perspective, should this gambit succeed, it would not only reduce the threat from Russia and the United States. It also makes breakout easier by reducing the length of the sprint from China’s supposed arsenal size to match—or exceed—the US and Russian arsenals. Finally, the Chinese Communists may also feel they face a “window of vulnerability” if Moscow and Washington discover their goal of becoming a peer nuclear power. If so, CCP leaders may be heeding the words of Deng Xiaoping, who declared the Chinese should “hide our capacities and bide our time…. Never take the lead—but aim to do something big.” Such fears will likely appear absurd to US policy-makers. If so, they
would benefit from examining Cold War history from the Chinese perspective.  

**Second-Tier Powers**

If the New START arms control regime holds, the next decade seems likely to witness the emergence of significant second-tier nuclear powers. To date, the value of even a modest nuclear arsenal in circumscribing the threats posed by the great nuclear powers has been demonstrated. The fate of Libya’s Muammar Qaddafi and Iraq’s Saddam Hussein—tyrants who sought but never acquired nuclear weapons—when contrasted to that of North Korea’s nuclear-armed ruling dynasty, now in its third generation, stands as a clear object lesson to the leaders of countries like Iran.

Today, minor nuclear powers have greater incentives to expand their arsenals to second-tier status, defined here as roughly a third to half that of the New START limits (or around 500–800 weapons). Arsenals in the 400–500 range were minor factors during the Cold War when the US and Russian nuclear inventories each numbered 20,000 weapons or more. They cannot be easily discounted in a world where American and Russian strategic nuclear forces have each been reduced by more than 90 percent. By New START constraining US and Russian arsenals, it also greatly reduces the barrier to other states achieving “great nuclear power” status. It’s one thing to build an arsenal of a thousand weapons and delivery systems. It’s quite another to construct and maintain one ten or twenty times greater, as was the case for any country during the Cold War era contemining matching the superpowers’ arsenals. Of course, the New START limits remain in effect, achieving second-tier status could simply be a way station on the path to achieving first-rank status.

Under a New START regime, even second-tier powers can play an outsized role in a tripolar competition among China, Russia, and the United States, especially if the major powers’ arsenals are in rough balance. Recall that both North Korea and Pakistan have ongoing nuclear modernization and expansion efforts, including fissile material production. If China’s expanding nuclear arsenal finds India following suit, we could see the Asian nuclear arsenals expanding significantly, and perhaps dramatically.

From Washington’s perspective, a reasonable worst-case scenario would find the United States trying to affect a stable nuclear balance against the Chinese and Russian arsenals while sustaining an effective extended deterrence posture. At the same time, prudence would dictate a need to hedge against the possibility that Pakistan, North Korea, or both could align themselves with China. This would present United States defense policy-makers with a problem similar to that confronted by their Soviet counterparts during the Cold War when Moscow had to account for the nuclear forces of Great Britain and France, as well as those of the United States. The big differences, of course, are that America’s European allies’ combined arsenals at that time were miniscule compared to Russia’s, and Moscow confronted only one principal rival, not two.

In brief, if New START remains in place, second-tier nuclear powers will likely have the means and motive to become significant players in the nuclear competition by the 2030s. The United States would be prudent to maintain a modern deterrent not only to hedge against China’s emergence as a great nuclear power and the advent of a tripolar nuclear regime, but also to discourage (or, failing that, to be capable of responding to) the appearance of second-tier nuclear powers.

**A Multidimensional Strategic Competition**

Nuclear weapons seem certain to remain the ultimate means for striking strategic targets—those that are central to a state’s material capability or will to prosecute war and to function as a society. However, advances in military-related technologies are changing the character of the strategic competition in significant, and potentially profound, ways. As revealed in the First Gulf War and confirmed in major US military operations since, the Precision Warfare Revolution finds conventional weapons
increasingly capable of effectively striking some targets formerly reserved solely for nuclear weapons.\textsuperscript{130}

The US advantage in this form of warfare has long concerned both Chinese and Russian military theorists and defense policy-makers. The 2013 version of \textit{Science of Military Strategy} notes that China faces a more "complex" nuclear environment, in part due to "the increasing sophistication of some major powers’ conventional military capabilities, with the US development of prompt global strike a particular concern, given the potential to target China’s nuclear weapons with conventional strikes."\textsuperscript{131} Russian defense expert Alexi Arbatov similarly observed over a decade ago that "Russian policy makers worry that... US strategic conventional precision-guided weapons (cruise and ballistic missiles) have a growing counterforce capability, meaning that they increasingly pose a threat to Russia’s nuclear capabilities."\textsuperscript{132} Echoing Chinese fears, Arbatov stated, "The main unspoken assumption behind this threat perception is that traditional nuclear deterrence may not be effective against conventional counterforce threats, since nuclear retaliation in case of such an attack would invite suicide by follow-on nuclear strikes and thus lacks credibility."\textsuperscript{133} [Emphasis added.]

The US development of precision warfare combined with Russia’s fielding of increasingly discriminate nuclear weapons has blurred the once bright distinction between conventional and nuclear use, complicating calculations of what constitutes a strategic weapon and how best to ensure strategic deterrence. Consequently, both China and Russia have moved to offset the US advantage in precision warfare by enhancing their nuclear forces and, especially in China's case, by attempting to match US precision-warfare capabilities. Now, thirty years after the First Gulf War, the United States has lost its dominance in this form of strategic warfare, even as its two principal rivals are also moving forward on a broad-based modernization of their nuclear triads.

Further complicating matters, it appears that cyber weapons may be able to strike some strategic targets effectively, such as those comprising a state's critical infrastructure, including its power grid, transportation system, and financial sector.\textsuperscript{134} Recent ransomware attacks on key US economic targets by non-state groups may only hint at the scale and potency of Chinese and Russian cyber arsenals.

Nor can US defense planners ignore the potential of hypersonic missiles, whose speeds exceed Mach 5, in calculating the strategic balance. Conventional warheads on these missiles are capable of inflicting substantial damage simply by virtue of their enormous kinetic energy.\textsuperscript{135} As Admiral Richard notes, "While not a replacement for nuclear weapons, new classes of hypersonic weapons will complement and enhance strategic deterrence and can deliver surgical strikes to provide effects or be integrated into larger campaigns, increasing the effectiveness of our warfighting advantages."\textsuperscript{136}

The Precision Warfare Revolution and likelihood of an emerging new military revolution that incorporates cyber and hypersonic weapons strongly suggest that nuclear weapons have lost the monopoly they have held on strategic warfare since their inception. The US military, which for several decades held a commanding lead in precision warfare, finds that lead dissipating, if it has not disappeared entirely. Moreover, new forms of warfare, such as those involving cyber weapons and hypersonic vehicles, find China, Russia, and other military powers actively engaged in their development. Simply put, non-nuclear strategic warfare is no longer a major source of US military advantage. Moreover, nuclear weapons are no longer the only means by which to destroy large numbers of strategic targets with a high confidence of success.

\textbf{Summary}

Today's strategic rivalry is vastly different from that of the Cold War era. And the nuclear competition's characteristics are highly unlikely to remain static, or to evolve in ways favorable to the United States.
By the time its planned triad modernization effort is completed in the mid-2030s, it seems highly likely the United States will confront a tripolar competition with China and Russia, enabled by the radical reductions in US and Russian Cold War nuclear arsenals and China’s nuclear modernization and arsenal expansion program. A tripolar nuclear competition could see each of the three major powers feeling pressured to hedge against the possibility that its two rivals might create an alliance against it. This could trigger an arms race, ending the New START regime.

Related to this are concerns that China or Russia could attempt to increase its arsenal size dramatically on relative short notice, a phenomenon known as breakout. It appears the CCP will, through accident or design, have a breakout option before the US triad modernization effort is completed. Given the absence of constraints on China’s missile forces, and the lack of CCP transparency with respect to its fissile material stocks, US policy-makers would be foolish to discount the possibility of a Chinese breakout.

If the New START arms control regime holds, the next decade seems likely to witness the emergence of significant second-tier nuclear powers. This is because under a New START regime, even second-tier powers can play an outsized role in a tripolar competition among China, Russia, and the United States, especially if the major powers’ arsenals are in rough balance. This could pose problems for the United States, since in a reasonable worst-case scenario it might have to account for Chinese and Russian arsenals while hedging against the possibility that prospective second-tier powers, such as Pakistan and North Korea, could align themselves with China.

Also, as revealed in the First Gulf War and confirmed in major US military operations since, the Precision Warfare Revolution finds conventional weapons increasingly capable of effectively striking some targets formerly reserved solely for nuclear weapons. Consequently, both China and Russia have moved to offset the US advantage in precision warfare by enhancing their nuclear forces and, especially in China’s case, by attempting to match US precision-warfare capabilities, including cyber weaponry. Now, thirty years after the First Gulf War, the United States has lost its dominance in this form of strategic warfare, even as its two principal rivals are also moving forward on a broad-based modernization of their nuclear triads.

While there are no guarantees that any of these shifts will occur, the odds of at least two of these futures coming to pass is highly likely; indeed, one—a multidimensional competition—is generally conceded to have arrived. As a result, any thorough assessment of the US nuclear modernization program must take these new aspects of the competition into account.
V. CLOSING THOUGHTS

When calculating the force required, we must be conservative in all our estimates of a potential aggressor’s capabilities and his intentions. Security depends on assuming a worst plausible case, and having the ability to cope with it.¹³⁷

—Former Secretary of Defense
Robert S. McNamara
Kennedy and Johnson Administrations

In this era of partisan political clashes, it is often difficult to find common ground on an issue, and even more difficult to witness a broad consensus. Yet there is broad agreement among the political class and defense experts that the US military’s highest priority is deterring a general nuclear war. A member of the arms control community puts it this way:

Strategic stability rests on rational cost-benefit calculations indicating that no political or military gain would justify initiating the use of nuclear weapons. This determination must remain robust under all conditions, including worst-case scenarios in which massive surprise strikes succeed in comprehensively destroying the opposing strategic forces in their underground silos, submarine pens, and air bases.

Photo: An artist’s rendering of the B-21 Raider with Edwards Air Force Base, California, as the backdrop. (Northrop Grumman via US Air Force)
Although such scenarios strain credulity, the United States would be prudent to hedge against them in deploying and modernizing its nuclear forces and their supporting C3 and early-warning networks.\textsuperscript{138}

The US nuclear deterrent’s core capabilities, the product of programs conceived between forty and sixty years ago, have aged to the point where they must be retired or, like the old jalopy leaking oil in the driveway, find its owner paying as much to maintain it as replace it. Recognizing this, the United States has begun updating its nuclear deterrent.

**Major Findings**

While preserving a strong nuclear deterrent has broad support, a debate has ensued over the best way to accomplish this. A few aspects of the modernization effort have broad support, especially preserving the sea-based SSBN force (albeit at reduced levels) and upgrading the NC3 infrastructure. That said, many of the program’s elements have attracted opposition from some quarters of the strategic studies community, especially from arms control advocates.

Those opposing triad modernization fear the program will trigger an arms race, and believe the program’s cost is excessive. They also express concerns over the program’s effects on crisis stability; question the need for maintaining its land-based leg in lieu of moving to a dyad; and doubt the need of keeping force levels as high as those permitted by the New START. This assessment finds the opposition’s concerns unpersuasive.

**Arms Race**

It’s difficult to see how US triad modernization risks triggering an arms race. The two revisionist great powers, Russian and China, are fully engaged in modernizing their triads. The Chinese are expanding theirs as well. Meanwhile, both North Korea and Pakistan continue producing the fissile material needed to increase their arsenal size. Simply put, those nuclear powers of concern to the United States are modernizing, and in most cases, expanding their arsenals. If there is a modernization race, the United States finds itself having moved only a few steps out of the starting gate.

**Cost**

The program’s cost is not trivial, but neither is it a budget buster. If one spreads the cost over the life of the forces that will emerge from the program, it constitutes a small fraction of the overall defense budget. Nuclear modernization will consume less than 4 percent of the defense budget at its highest point in the late 2020s and early 2030s. Overall, the Defense Department projects it will spend less than 10 percent of its budget annually on operating, sustaining, and modernizing the country’s nuclear deterrent.\textsuperscript{139} It’s worth noting that the entire defense budget is less than 3 percent of US GDP—or less than half its average share during the Cold War, the last period of intense great power rivalry.

Extending the life of the Minuteman ICBM force and Trident SSBN fleet is no longer possible. Delaying modernization risks eviscerating the US deterrent as forced retirements set in later this decade. The problem would be compounded by eroding the industrial base’s production plant and equipment, as well as its skilled workforce. Indeed, the idea that American industry is an “arsenal of democracy” that can be put to work at a moment’s notice belongs to a bygone era.

**Cost Imposition**

Critics of the program’s cost also tend to ignore the fact that a good strategy imposes disproportionate costs on rivals. This tends to make them less willing to pursue the competition, or compels them to compete at a significant disadvantage. This is the case with the triad modernization program’s land-based missile force and long-range bomber fleet, which impose disproportionate costs on US rivals seeking to neutralize these forces. The GBSD force does this by presenting enemies with an unfavorable attack weapon exchange ratio of 2:1 or (likely) worse. Defending against the bomber force finds enemies ex-
pending resources an order-of-magnitude greater than those required to field and maintain the bombers—and without success. Thus, triad modernization enhances deterrence by driving up rival costs and (in the case of bombers) diverting adversary resources into less threatening areas (such as integrated air defenses) of the competition.

Crisis Stability
Concerns relating to crisis stability center primarily around the triad’s land-based leg. In particular, there are fears that the ICBMs will be forced to assume a hair-trigger launch posture. This stems from their fixed locations, which are well known to enemies, and their short attack warning time—perhaps 20 minutes or so before the incoming warheads arrive. Hence the assumption that these missiles must be launched on warning of an attack, requiring them to be on high alert, thereby increasing the risk of an accidental or unauthorized launch. This misses the point regarding the land-based deterrent’s principal value: as a deterrent force, not a warfighting force. By imposing disproportionate costs on an attacker, the incentive to attack is reduced, and deterrence is enhanced. In brief, the land-based deterrent’s value resides far more in its ability to deter an attack, than being launched in the wake of an attack—in deterring a nuclear war, rather than fighting one. More broadly speaking, the triad’s mutually reinforcing components, where each leg has its unique advantages that offset the shortcomings of the other two, greatly complicates an enemy’s planning and, in so doing, further reduces the risk of war.

Dyad
Advocates such as former defense secretary William Perry assert that “any sane nation would be deterred by the incredible striking power of our submarine force.” Yet this statement contradicts Perry’s declaration prior to the Chinese and Russian nuclear programs moving into high gear:

The triad of strategic delivery systems continues to have value. Each leg of the nuclear triad provides unique contributions to stability. As the overall force shrinks, their unique values become more prominent.

Indeed, those advocating a dyad comprising the bomber and submarine components have not presented a compelling argument for why the land-based leg detracts from deterrence or that it is prohibitively costly. Nor have they explained how concentrating America’s nuclear “eggs” in a few submarine “baskets” strengthens deterrence. Moreover, China and Russia are modernizing their triads, which implies they believe deterrence is best served by maintaining this posture.

The SSBN leg of the triad is currently the most survivable, at least those submarines on patrol at sea. Yet there is considerable risk in assuming that there will be no major advances in undersea detection technology or threats to SSBN command-and-control links over the Columbia-class’s service life, which stretches far beyond the middle of this century. Moreover, the idea that the SSBN force can be reduced from today’s fourteen boats to ten, instead of the twelve programmed, ignores the fact that even twelve Columbia-class boats will be unable to meet their operational requirements as part of a triad unless the boats’ maintenance requirements are substantially less than the Ohio-class that preceded it.

Deep Cuts
Finally, there are some who argue the United States would be just as secure if it reduced its forces significantly below New START levels. Yet, again, it’s difficult to see the logic in how the US cutting its forces increases the strength of its deterrent while hostile powers are modernizing and, in most cases, increasing theirs.

A Vastly Different Tomorrow?
Many American defense policy-makers, military leaders and members of the strategic studies community are paying considerable lip service to the view that triad modernization is oc-
curring at a time of great change, a geostrategic inflexion point, in the security environment. Yet the ongoing debate is heavily rooted in assumptions that the current competitive environment—dominated by the twin US and Russian arsenals that are constrained by New START and populated by a handful of far lesser nuclear powers—will endure and remain in place at the time US triad modernization is completed.

These assumptions are increasingly fanciful. Indeed, it’s almost certain that the strategic nuclear competition will have experienced several disruptive shifts by the mid-2030s.

First, US policy-makers can hardly discount the prospect that the long US-Russian bipolar competition will become tripolar in character, with China joining them in the Nuclear Club’s first rank. Estimates of China’s arsenal are, to a significant extent, based on faith in the CCP’s declarations and on unconfirmed estimates of its fissile material stocks. Evidence is growing that China is determined not to be a second-class citizen regarding nuclear arms. Exhibit A is its ongoing nuclear modernization and expansion program, which is projected to at least double China’s nuclear arsenal by decade’s end. How this could occur given its supposed fixed fissile material assets is a matter of some speculation. It’s possible that China has been producing fissile material, and/or that it can acquire it from its two nuclear proteges, North Korea and Pakistan, both of whom are actively producing highly enriched uranium and plutonium. This would square with China’s developing the DF-41 ICBM, capable of carrying ten warheads, and constructing over 200 new missile silos while fielding a separate road-mobile ICBM force.

If a tripolar great nuclear power regime were to emerge, parity—long a key component of Russian-US arms control agreements—would no longer be possible. Correspondingly, establishing and maintaining a US deterrent capable of providing an assured destruction capability against two comparably armed powers would prove challenging. Doing so while preserving today’s level of deterrence seems especially daunting.

Second, there exists significant potential for breakout, a relatively rapid and significant shift in the nuclear balance. China is unconstrained by New START and has several new ICBMs in development or production, including the DF-41. Nothing precludes the CCP from stockpiling missiles or warheads. The large number of missile silos now being constructed in China could house a few missiles, or many. Similarly, the PLA could easily expand its mobile launch systems. The Russians have a new ICBM that can accommodate four MIRVs, and another under development that can be armed with ten or more. They also clearly have sufficient fissile material stocks to support a rapid expansion of their arsenal. The guessing game associated with the arsenal size of totalitarian regimes like those of China and North Korea highlights the difficulty of knowing with confidence how many nuclear weapons these states might possess with which to arm their growing number of modern strategic delivery systems.

Third, the rise of second-tier nuclear powers—those with a third to half of the weapons permitted under New START—cannot be discounted. Indeed, it appears that if the New START agreement is sustained over time, perhaps even incorporating a Chinese strategic nuclear force, then lesser nuclear powers could be incentivized to expand their arsenals to second-tier status to enhance the value of their geopolitical alignment. Consider, for example, a United States confronted with establishing a high-confidence assured destruction capability against Russia and China within the context of the New START, and having to address the threat posed by second-tier North Korean (and perhaps Pakistani) arsenals were they to align with China. The implications for the credibility of US pledges of extended deterrence are obvious.

That being said, were the New START regime to collapse in the wake of a Chinese ascent to great nuclear power status,
an arms race could ensue. If so, prospective second-tier nuclear powers would have far less incentive to expand their arsenals to the high triple digits, similar to the British, Chinese, and French Cold War era forces, since they would exert only an extremely modest influence on the competition among the great nuclear powers.

Finally, US policy-makers cannot ignore the emergence of multidimensional strategic arsenals, which stems from the growing number of non-nuclear forces capable of attacking with confidence a significant number of strategic targets once reserved for nuclear forces. The United States’ advantage in precision warfare, a major source of advantage in the two decades following the Cold War’s end, is greatly diminished, and may no longer exist at all with respect to China. Moreover, as recent events suggest, cyber weapons also have the potential to hold at risk key elements of advanced states’ critical infrastructure. Then there are the hypersonic missiles, which appear increasingly likely to exert a significant influence on the strategic balance.

Ignoring these prospective developments requires a healthy dose of willful ignorance. One, the emergence of multidimensional strategic arsenals, is already here. One of two others—the advent a tripolar nuclear power competition and the appearance of second-tier nuclear arsenals—appears likely to emerge. Both could occur if the current arms control regime maintains its cap on arsenal size and a new arms race (break-out) is avoided.

The Bottom Line
Current circumstances strongly support triad modernization. Likely shifts in the character of the strategic competition—both geopolitical and military technical—serve only to increase the value of proceeding. Indeed, given current trends it would, at the least, seem prudent to hedge against the prospect that some will quite likely play out. If so, the United States’ options for addressing such shifts in the threat environment would be greatly enhanced by maintaining a modern nuclear deterrent supported by a healthy industrial base.
APPENDIX A: UNCERTAINTIES OF A NUCLEAR ATTACK ON THE US LAND-BASED DETERRENT

During the Cold War, the Defense Department and members of the strategic studies community conducted extensive analysis to determine the land-based deterrent’s vulnerability to attack. An attacker’s prospects for success turned out to be a function of many factors, principal among them: the yield of the incoming warhead, its accuracy, and the hardness of the silo housing the targeted ICBM.

Since an attacker could not count on its warheads being perfectly accurate, to achieve high confidence in destroying the missile silo and its contents, or rendering it unable to launch its missile to the job. For example, attacking each silo with a single warhead that is 90 percent accurate (in terms of kill probability) would find roughly 40 of 400 targeted ICBMs surviving the attack. Statistically speaking, adding a second warhead against each silo would reduce the survivors to four.

But things are not that simple for the attacker, who must also account for the likelihood that some of its missiles may malfunction during their boost phase. Although the accuracy, reliability and yield of a prospective attacker’s nuclear-armed ballistic missile warheads can be refined through testing, there is also the matter of the target’s silo hardness. The overpressure at which a silo will fail depends on the technical characteristics of the reinforced-concrete door at the top of the silo, which the attacker may not know with high confidence. Moreover, during the latter stages of the Cold War, the open-source literature suggested that silos could be “super-hardened” to between 20 and 40 times their existing strength.

There is also an issue with respect to an attack’s timing. An attacker cannot reasonably assume that its attacking warheads detonate statistically independent of each other—that an individual warhead’s detonation has no bearing on other warheads being employed in an attack. Thermonuclear warhead explosions can significantly degrade the effectiveness of other incoming warheads. This is because a warhead’s explosion generates a brief but intense burst of radiation, creating a powerful electromagnetic pulse. A rapidly expanding fireball moving faster than the speed of sound follows, creating hurricane-force winds. A warhead set to detonate at an optimum height to neutralize a silo hardened to 2,000 pounds per square inch (psi) will result in a fireball contacting the ground. The effect will generate thousands of tons of dust and other debris, boiling up rapidly and forming the weapon’s signature mushroom cloud. The clouds generated by an attack on the entire Minuteman field would cover it completely. This creates significant problems for successive attacking warheads. A follow-on warhead will arrive moving at roughly four miles per second. At this speed, even if it was struck by a small particle weighing a few ounces, it could be destroyed outright. Passing through the cloud’s smaller particles would find the warhead buffeted by what might be described as the effects of a powerful sandblaster. This combination of winds, the warhead’s speed, and the effects of passing through the mushroom cloud debris would severely degrade the follow-on weapon’s accuracy.

Given these considerations, it’s not surprising that former defense secretary James Mattis stated it could require an attacker to allocate as many as four warheads to be highly confident of destroying a US land-based missile in its hardened silo. If so, and assuming the New START limits are in effect, a high-confidence attack on the US land-based missile leg would consume Russia’s entire strategic nuclear arsenal.
APPENDIX B: COST ESTIMATES

It’s been said there are three kinds of lies: lies, damned lies, and statistics. The phrase refers, of course, to the persuasive power of numbers—and their malleability. This appendix offers a modest overview of military program cost estimates.

Cost estimates are just that: estimates. Program estimates are based on myriad assumptions. The more complicated the program in question, typically the more challenging it is to arrive at an accurate estimate of its ultimate cost. Estimates also rely heavily on similar past programs. For example, accurately estimating the cost of a fifth-generation system with data accumulated from the four earlier generations would likely be easier than estimating the cost of a first-generation system.

There are also temporal factors to consider. If the previous generation of a particular system, as in the case of the three triad delivery systems, was produced forty or fifty years ago, historical data may prove poor guides for estimating cost, as production infrastructure, new design methods, the labor force, and component technologies, among other key factors, may have changed significantly, and perhaps dramatically.

Cost estimates themselves often come in different “flavors.” Among the differing ways in which costs may be presented are:

- The kinds of cost components that are included, such as research and development, production, and operations and maintenance costs.
- The time frame in which costs are incurred. How long is the system in question likely to be in service—ten years? Fifty?
- Whether costs are presented in “then-year” (nominal) or “constant-year” (adjusted for inflation) dollars (with the latter, of course, requiring estimates of inflation).

Thus, for example, in the case of the GBSD, recent estimates for its lifetime cost range from $112 to $267 billion, depending upon the period considered (which ranges from 30 to 60 years), the cost components considered or excluded (such as research and development, procurement, operations and maintenance, and military construction); and whether nominal or inflation-adjusted dollars are used.


3. As defined in this assessment, deterrence involves efforts to prevent a competitor (the object or “target”) from pursuing a proscribed action. Deterrence seeks to influence the target’s calculation of the costs, benefits, and risks associated with pursuing the proscribed action. Assuming a rational target, deterrence works by convincing the target that it has an unacceptably low probability of achieving its goals (deterrence through denial), or that the costs involved in pursuing the proscribed action will exceed any benefits derived (deterrence through punishment).


8. In its initial formulation, assured destruction was viewed as the ability of each leg of the triad to destroy independent of the others roughly 25 percent of Soviet Russia’s population and industry. Newhouse, War and Peace, 164.


12. Ambassador Wood is the Biden administration’s US permanent representative to the Conference on Disarmament.


15. Stewart, Russia Military, 22-23.


17. Russian doctrine also includes the possibility of launching a retaliatory strike should it detect a nuclear attack is underway against it, typically referred to as “launch on warning.” The June 2020 policy document describes a number of circumstances under which Moscow might consider the use of nuclear weapons. This includes when it has received “reliable data on a launch of ballistic missiles attacking the territory of the Russian Federation and/or its allies” and in response to the “use of nuclear weapons or other types of weapons of mass destruction by an adversary against the Russian Federation and/or its allies.” Russia also reserves the right to respond with nuclear weapons following an “attack by [an] adversary against critical governmental or military sites of the Russian Federation, disruption of which would undermine nuclear forces response actions” and “aggression against the Russian Federation with the use of conventional weapons when the very existence of the state is in jeopardy.” Ministry of Foreign Affairs of the Russian Federation, On Basic Principles of State Policy of the Russian Federation, Moscow, June 2, 2020, paras. 4, 5, 10, and 19, https://www.mid.ru/en/web/guest/foreign_policy/international_safety/disarmament/-/asset_publisher/rp0fIUBmANaH/
Given that Russia is a kleptocracy, the “state” may also be interpreted as the “regime.”


Woolf, “Russia’s Nuclear Weapons,” 15, 23. Some sources believe the Sarmat can carry fifteen warheads, as well as penetration aids, and several Avangard hypersonic glide vehicles. Russia may also be developing other missiles, including an intermediate-range version of the SS-27 Mod 2 (known as the RS-26) and a rail-mobile ICBM, known as Barguzin.


Office of the Secretary of Defense, 87.

Richard, Testimony, 6.

Office of the Secretary of Defense, Military and Security Developments, 87; and Richard, Statement, 4.

The strategic arsenal is complemented by road-mobile, solid-fueled CSS-5 Mod 2 and Mod 6 (DF-21) MRBMs and DF-26 IRBMs capable of ranging targets in the Indo-Pacific region. Office of the Secretary of Defense, Military and Security Developments, 86. See also Charlie Gao, “China’s Missile Arsenal Got Some Help from an Unlikely Source: Ukraine,” National Interest, May 16, 2021, https://nationalinterest.org/blog/reboot/chinas-missile-arsenal-got-some-help-unlikely-source-ukraine-185284. IRBMs have a range of 3,000-5,500 kilometers (km); an MRBM’s range is between 1,000 and 3,000 km.

Office of the Secretary of Defense, Military and Security Developments, 86-87; and Richard, Statement, 5.


Richard, Testimony, 3.

The National Security Advisory Group, “Reducing Nuclear Threats and Preventing Nuclear Terrorism,” Harvard University, Ken-
See for example, Bruce Blair et al., “Smaller and Safer: A New Plan for Nuclear Postures,” Foreign Affairs (September/October 2010), https://www.foreignaffairs.com/articles/russian-federation/2010-09-01/smaller-and-safer. The authors assert that “the United States and Russia could limit their strategic nuclear arsenals to a total level of 1,000 warheads each on no more than 500 deployed Launchers without weakening their respective security.”


Global Zero, 1–2.


One Trident warhead (the W88) has a yield of 455 kilotons, exceeding the 335-kiloton yields of the Minuteman III’s warhead. David Wright, William D. Hartung, and Lisbeth Gronland, “Rethinking Land-Based Nuclear Missiles,” Union of Concerned Scientists, June 2020, 11.


The land-based deterrent is fixed in its location by design, not out of necessity. Both China and Russia have mobile land-based missiles as part of their triad.


Some analysts argue that an attacker could simply target the Minuteman III’s forty-five underground launch centers controlling the 400 missiles, while simultaneously taking out the airborne command and control center and the sites’ UHF antennas. Blair, “The End of Nuclear Warfighting,” 80. This assumes, of course, that an attacker would be comfortable accepting the risk that such an effort might fail, leaving it with the problem of nearly 400 fully operational US ICBMs.


Richard, Testimony, 13.


Miller, “Facts Matter.”


Five Columbia-class SSBNs, each with sixteen missiles, each armed with eight warheads, gives 5 x 16 x 8 = 640 total weapons. Currently, SLBMs appear to be armed with four or five warheads. The D-5 missile has been successfully tested armed with eight RVs. Of course, only a fraction of the SSBN force is on patrol at any given time. Woolf, “US Strategic Nuclear Forces,” 50; and Ronald Gutzridge, “USS Nebraska Successfully Tests Trident II D5 Missile,” Navy News Service, March 29, 2018, https://www.cpf.navy.mil/news.aspx/110474.

It is asserted that a minimum deterrence-only strategy would enable the United States to reduce its operationally deployed nuclear weapons to 650 from 1,550, making the triad’s other two legs “redundant and dispensable.” Blair, “The End of Nuclear Warfighting,” 5, 10.

Blair, 74-75.

Blair, 73.

Blair, 76.

Unlike any other US submarine, Columbia will have an integrated electric propulsion system, whereas Ohio has a traditional, “tried and true” steam turbine system. While the integrated propulsion system has been prototyped ashore at high power over extended runs, this does not guarantee reliability over decades in an at-sea environment.

This option is even less attractive than when originally proposed, as construction on the USS Columbia (SSBN 826) began on October 1, 2020. Construction could, of course, be halted, but it would increase costs, throw the industrial base workforce into chaos, and risk having key lower-tier firms exit the business.

Miller, “Never Let a Good.”


In testimony, the then Air Force deputy chief of staff for Strategic Plans, Programs, and Requirements stated that the United States needed a fleet of 165 bombers, with 100 B-21s. Air Force Secretary Heather Wilson announced a goal of seven additional bomber squadrons, which could require roughly 175 B-21s. John A. Tipps, “It’s Official: Minimum of 100 B-21s,” AirForce, March 16, 2017, http://www.airforcemag.com/DRArchivePages/2017/March%202017/March%2015%202017/It%E2%80%99s-Official-Minimum-of-100-B-21s.aspx; and Secretary of the Air Force Public Affairs, Air Force We Need: 386 Operational Squadrons, September 17, 2018, https://go.usa.gov/xPXAg.


Richard, Testimony, 15-16.

Miller, “Never Let a Good.”


Blair, “The End of Nuclear Warfighting,” 40.

See, for example, Perkovich and Vaddi, Proportionate Deterrence, 6; Blair, “The End of Nuclear Warfighting,” 40-42; Richard, Testimony, 4, 14-15, 18-20; and Richard, Statement, 16-17.

Blair, “The End of Nuclear Warfighting,” 42.

There are, for example, some who believe the Israeli attack on September 6, 2007, against a Syrian nuclear reactor under construction was facilitated by a cyberattack that corrupted the Syrians’ IADS. Richard A. Clarke and Robert K. Knake, Cyber War (New York: Harper Collins, 2010), 7.

Blair, “The End of Nuclear Warfighting,” 42. See also, Andrew Futter, Hacking the Bomb: Cyber Threats and Nuclear Weapons (Washington, DC: Georgetown University Press, 2018).

Richard, Testimony, 18-21. Among the modernization program’s priorities are modernizing the triad’s NC3 systems associated with the US military’s command-and-control airborne platforms, including the E-4B National Airborne Operations Center and E-6B Airborne Command Post (“Looking Glass”)/Take Charge and Move Out aircraft. Priority is also being given to enhancing NC3 space-based protected satellite communication capabilities, along with upgrades to the system’s Very Low Frequency and Low Frequency survivable communications, which will extend their range, enhance their security, and enable more rapid transmission.

“Recall” can be viewed in different ways, depending upon whether the focus is on the delivery system or the weapon. For example, an SSBN, like a bomber, can depart its base. What cannot be recalled is an SLBM. But an LCOS air-launched cruise missile launched from a B-21 can’t be recalled, either. The difference is US bombers are not carrying nuclear weapons while airborne. Thus, launching them with nuclear weapons onboard would send a strong signal to an adversary of how seriously the US government views the situation. And aircraft being recalled after launch can provide a visible de-escalation signal to an enemy, something that would not be apparent if an SSBN were ordered to return to port.

The United States possessed over 30,000 nuclear weapons by the early 1960s and over 20,000 at the Cold War’s end. By the early 1960s, the Soviet Union had several thousand weapons, with its inventory peaking in the mid-1980s at over 40,000. When the Berlin Wall fell, the USSR’s nuclear weapons inventory stood at over 35,000. Natural Resources Defense Council, “Table of US Nuclear Warheads,” http://www.nrdc.org/nuclear/nudb/datab9.asp and “Table of USSR/Russian Nuclear Warheads,” http://www.nrdc.org/nuclear/nudb/datab10.asp. By contrast, Great Britain’s nuclear forces never exceeded 400 weapons, while France’s inventory peaked at roughly 500. China’s nuclear arsenal is believed never to have numbered more than some 450 weapons. Natural Resources Defense Council, “Table of Global Nuclear Weapons Stockpiles, 1945–2002,” http://www.nrdc.org/nuclear/nudb/datab19.asp.


Richard, Testimony, 9-10.


Eric Heginbotham et al., China’s Evolving Nuclear Deterrent (Santa Monica, CA: RAND, 2017), 53-54.

Bruce W. Bennett et al., Countering the Risks of North Korean Nuclear Weapons (Santa Monica, CA: RAND and The Asian Institute for Policy Studies, 2021), 39.


Bennett et al., Countering the Risks, 20-21, 53-54.

Chinese strategists and planners have noted with concern Russia’s deployment of tactical nuclear weapons in the Far East. Heginbotham et al., China’s Evolving, 74.


IPFM, Global Fissile Material Report 2013, 31. Neither France nor Russia provides information on their fissile material levels.

One metric ton = 2,205 pounds, or 1,000 kilograms.

IPFM, Global Fissile Material Report 2013, 15, 17, 19, 24, http://fissilematerials.org/library/gfmr13.pdf. Hui Zhang, one of the foremost experts on China’s nuclear industry, has estimated that China will have an excess enrichmen capability of three million separative work units per year, meaning it will be able to produce around several hundred bombs’ worth of highly enriched uranium each year without sacrificing any of its nuclear energy needs. Hui Zhang, China’s Uranium Enrichment Capacity: Rapid Expansion to Meet Commercial Needs, Belfer Center, Harvard University, Kennedy School of Government, August 2015, https://www.belfercenter.org/sites/default/files/legacy/files/chinasuraniumenrichmentcapacity.pdf.


For an HEU-based nuclear weapon, there are two basic design options: a “gun-type” weapon where two pieces of HEU are brought together quickly and explode, and an “implosion” weapon, where a sphere of HEU is rapidly compressed in a highly symmetrical manner. Gun-type weapons are far simpler in design. The implosion design is more difficult technically but requires less HEU. Plutonium-based nuclear weapons work only as implosion weapons, with more sophisticated designs using less plutonium to achieve an equivalent yield.


106 In thermonuclear weapons, a fission nuclear explosion (the "primary") is used to generate X-rays that compress and ignite a second nuclear explosion (the "secondary"), comprising uranium and thermonuclear fuel. The energy released by the secondary is generated by both the fission of HEU and the fusion of deuterium and tritium. In the secondary, the tritium is produced during the explosion by neutron absorption in lithium-6. Felsveson et al., "Fissile Materials," 560.


109 Heginbotham et al., China’s Evolving, 127.


112 Bennett et al., Countering the Risks, 37.

113 Bennett et al., 52.

114 Kristensen and Korda, “Status of World Nuclear Forces.”


120 Richard, Testimony, 5, 9.

121 The latest estimate by the Federation of American Scientists puts the number at 350. Kristensen and Korda, “Status of World Nuclear Forces.”

122 The first Strategic Arms Limitations Treaty, SALT I, signed in 1972, placed ceilings on the number of strategic launchers each side could maintain, but did not include strategic bombers. SALT I was followed by SALT II, which limited the United States and the Soviet Union to 2,250 delivery vehicles each (ICBMs, SLBMs, and strategic bombers). The treaty was signed in 1979. Although the US Senate never ratified it, both countries pledged to abide by its terms. The first Strategic Arms Reduction Treaty (START I), signed in 1991, limited each side to 1,600 delivery vehicles carrying no more than 6,000 warheads. START II, signed only two years later, cut the number of weapons each side could possess by roughly half. By 2002, both countries had completed negotiations and signed the Strategic Offensive Reductions Treaty (SORT), reducing their strategic arsenals to between 1,700 and 2,200 weapons. In 2010 the New START agreement was signed, limiting each side to 1,550 strategic nuclear weapons. "US-Russian Nuclear Arms Control Agreements at a Glance," Arms Control Association, https://www.armscontrol.org/factsheets/USRussiaNuclearAgreementsMarch2010.


125 ICBMs are those with a range of 3,000–5,500 km, between the range of MRBMs (1,000–3,000 km) and ICMBs (over 5,500 km).

126 CSIS Missile Defense Project, "DF-41 (Dong Feng-41/CSS-X-20),"


147 Some analysts argue that an attacker could simply target the Minuteman III’s forty-five underground launch centers controlling the 400 missiles, while simultaneously taking out the airborne command and control center and the sites’ UHF antennas. This assumes, of course, that an attacker would be comfortable accepting the risk that such an effort might fail, leaving it with the problem of 400 fully operational US ICBMs. As noted elsewhere in this assessment, the GBSD program includes funding to enhance the force’s command and control element, to include cyber threats. Blair, “The End of Nuclear Warfighting,” 80; and Miller, “Facts Matter.”