APRIL 2020

On the Horizon

A Collection of Papers from the Next Generation

EDITOR
Simone Williams

AUTHORS
Mary Boatright
Rick Cassleman
Madison Estes
Sam Guthrie
Rafael Loss
Craign Neuman
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Kyle Yohe

A Report of the
CSIS PROJECT ON NUCLEAR ISSUES

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

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About the Project on Nuclear Issues

The Project on Nuclear Issues (PONI) was developed in 2003 to develop the next generation of policy, technical, and operational nuclear professionals by fostering, sustaining, and convening a networked community of emerging experts. PONI identifies and cultivates emerging thought leaders by building relationships, deepening understanding and sharing perspectives across the full range of nuclear issues and communities. PONI's programs provide inclusive, diverse, and creative opportunities for emerging experts to learn about policy, technical, and operational aspects of the nuclear enterprise; develop and present new concepts and ideas; engage in thoughtful and informed debates; and tour and visit sites across the nuclear enterprise.

PONI works to achieve this mission through several objectives:

- Identifying emerging thought leaders and providing them with the opportunity to develop and present new concepts and ideas.
- Sponsoring new cutting-edge research.
- Encouraging thoughtful and informed debate.
- Engaging a broad and diverse community across the country and internationally.
- Providing a networked platform for information-sharing and collaboration across the broad nuclear community.
- Cultivating young professionals through opportunities to build relationships, deepen understanding, and share perspectives across the full range of nuclear issues and communities.

PONI sponsors numerous opportunities for young professionals to engage in thoughtful and informed debate on the nuclear community's most pressing challenges.

PONI strives to expand its outreach to address all career and academic levels, connect young professionals in collaborative research projects, broaden the topics it covers across the full spectrum of nuclear issues, and ensure robust inclusion of expertise from all critical domains—academic, military, scientific, and technical.

1. Inclusivity – Welcome all ideas and perspectives across political, ideological and policy spectrums.
2. Diversity – Actively seek interdisciplinary perspectives (technical, operational, corporate, government, academic) and embrace participation across all demographics.

3. Creativity – Promote collaborative, innovative research and dynamic, engaging programming.

Amongst the various programming opportunities available through PONI, the authors in this publication were members of PONI's 2019 Nuclear Scholars Class. The PONI Nuclear Scholars Initiative is a group of select graduate students and young professionals. The Nuclear Scholars Initiative aims to provide top graduate students and young professionals from around the country with a unique venue to interact and dialogue with senior experts on nuclear weapons issues. Those accepted into the program are hosted once per month at CSIS in Washington, D.C., where they participate in daylong workshops with senior government officials, policy experts, and technical experts. Over the course of the six-month program, Scholars are required to prepare a research product. PONI has several alumni from this initiative, many of which continue to work in the nuclear field and are likely to play key roles in nuclear policy development, technical innovations, and operations.

Acknowledgments

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Introduction

The role that nuclear weapons play in international security has changed since the end of the Cold War, but the need to maintain and replenish the human infrastructure for supporting nuclear capabilities and dealing with the multitude of nuclear challenges remains essential. For a number of reasons, including the diminished emphasis on nuclear weapons post-Cold War, expertise on nuclear issues—particularly within younger generations—declined following the end of the Cold War. Cultivating the expertise that is critical to meeting the nuclear challenges of the future remains difficult despite efforts to rebuild and restore this essential cadre of talent and expertise.

Meeting the security challenges of the future will require a sustained effort over the long-term by a multidisciplinary cadre of nuclear experts who are equipped with critical knowledge and skills as well as a robust professional network. It will also require new and creative thinking on how to approach various political, military, legal, and technical challenges in the United States and around the world.

Recognizing this challenge, the Center for Strategic and International Studies (CSIS) launched the Project on Nuclear Issues (PONI) in 2003 to develop the next generation of policy, technical , and operational nuclear professionals by fostering, sustaining, and convening a networked community of emerging experts to meet the nuclear challenges of the future. PONI seeks to revitalize and strengthen the community of nuclear experts whose training and background increasingly emphasize multidisciplinary expertise, especially among young generations.

The Nuclear Scholars Initiative is a signature PONI program that engages emerging nuclear experts in thoughtful and informed debate over how best to address the nuclear community's most pressing problems. The papers included in this volume comprise research from participants in the 2019 Nuclear Scholars Initiative. PONI sponsors this research to provide a forum for facilitating new and innovative thinking and to provide a platform for emerging thought leaders across the nuclear community. The papers in this volume span a wide range of technical and policy issues and provide innovative recommendations for pressing challenges.

Moving Forward in a Post-INF World

Mary Boatright[1]

ABSTRACT

The future of the U.S.-Russian arms control relationship is in a nebulous state. Evolving global threats in the modern era and a swift return of the great power competition amongst states have challenged the very nature of arms control as the two powers with massive nuclear arsenals seek to justify realist strategic policies. The benign period in the U.S.-Russia relationship has come to a halt in the wake of egregious and illegal behaviors by the Russian Federation:[2] aggressive territorial annexation and arms control treaty encroachments. The bilateral withdrawal of the Intermediate-Range Nuclear Forces (INF) Treaty[3] is the latest catalyst to drive a deeper wedge of distrust between the United States and Russia. The United States and the North Atlantic Treaty Organization (NATO) have urged Russia to abide by international law and return to treaty compliance; however, Russia continues to obfuscate their actions. As the international community seeks a path forward in spite of fears of increased instability, it is imperative that the United States wields control of the arms control narrative in an effort to save future arms control agreements, assure allies, deter against further aggression, and promote international stability through arms parity.

INTRODUCTION

In the 1980s, the arms control dialogue between the Soviet Union, now Russia, and the United States was pivotal in progressively easing political and military tensions towards the end of the Cold War. Without this diplomatic engagement and mutual compromise, the bipolar powers might not have advanced toward improved relations. Mikhail Gorbachev's signature reforms—*perestroika* and

1. Mary Boatright is a captain in the U.S. Air Force. She serves as a flight commander in the 741st Missile Squadron in support of Minuteman III nuclear operations at Minot Air Force Base, North Dakota. The views expressed in this paper are those of the author only and do not reflect official policy or position of the U.S. Air Force, Department of Defense, or the U.S. government.
2. For brevity purposes, the Russian Federation will be referred to as Russia.
3. The Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Elimination of Their Intermediate-Range and Shorter-Range Missiles, also known as the INF Treaty.

glasnost—were a nod to the legitimacy and efficacy of Western ideals and concepts that helped forge the existence of the landmark arms control agreement in 1987: the INF Treaty.[4] This treaty became a major arms control agreement prior to the fall of the Berlin Wall. This signaled assurance to the world that mutual arms control was critical in cultivating both regional and international stability. This was not just a military tool, but also a political one. It was a pioneer in its kind, as it guaranteed the elimination of production, stockpiling, and fielding of Intermediate-Range Ballistic Missiles (IRBMs) and Ground Launched Cruise Missiles (GLCMs), effectively eradicating an entire class of nuclear weapon delivery systems. The intent was rooted in reducing the "risk of outbreak of war" coupled with "strengthening strategic stability."[5] According to reports made by the Defense Threat Reduction Agency's (DTRAs) On-Site Inspection Agency (OSIA), there was an aggregate 2,692 missiles that were eliminated between 1988 and 1991, with the Soviet Union eliminating nearly one thousand more missiles than the United States.[6] Indeed, this was a monumental diplomatic agreement of its time. Recently, however, both the United States and Russia have ascertained that the INF Treaty is not in their national interests and have severed obligations to the terms, leading to its inevitable demise. This was not incredibly surprising. Prior to U.S. treaty withdrawal, the 2018 Nuclear Posture Review (NPR) suggested that if violations continue, the United States would "not forever endure" Russian noncompliance as it diminishes predictability and that doing so would be "untenable."[7]

This mutual decision has ripened the political landscape for renewed international challenges. The emergence of regional hegemonic powers, a threat miscalculation leading to escalation, and a possible renewed arms race in Europe are challenges that the United States and Russia face as the relationship regresses. With increased skepticism, the future appears to be bleak for other agreements such as the New Strategic Arms Reduction Treaty (New START),[8] which is set to expire in 2021 unless an extension is approved.

This paper explores the definitions and applications under the umbrella of arms control, the bilateral nature of the treaty, and a mismatch in parity as perceived by Russia. Additionally, the goal of this paper is to offer ways forward in spite of INF's demise. With a more insightful understanding, the hope is that evolving dialogue may be further advanced. The United States and Russia must take deliberate efforts to fill this void to ensure security cooperation and confidence-building in both allies and adversaries alike.

ARMS CONTROL AND HISTORICAL APPLICATIONS

When discussing arms control components, it is important to identify terminology as it provides a baseline with a clear understanding of security goals. Arms control, arms reductions, and disarmament are terms that many treat as interchangeable, but are not. As such, it is crucial to apply the appropriate

4. These policies were effective between 1986-1991, during the Gorbachev era. These policies were intended to improve the Soviet economy (through restructure) and create a more vibrant political environment through an open communication (e.g., freedom of expression) forum between the populace and the government.
5. "Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Elimination of Their Intermediate-Range and Shorter-Range Missiles (INF Treaty)," U.S. Department of State Archives, https://2009-2017.state.gov/t/avc/trty/102360.htm.
6. Joseph P. Harahan, *On-Site Inspections Under The INF Treaty, A History of the On-Site Inspection Agency and Treaty Implementation, 1988-1991* (Washington, DC: The On-Site Inspection Agency, 1993): 34.
7. U.S. Department of Defense, *2018 Nuclear Posture Review* (Washington, DC: U.S. Department of Defense, 2018): 74. https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.
8. The treaty between the United States of America and the Russian Federation on Measures for the Further Reduction and Limitation of Strategic Offensive Arms, also known as the New START Treaty.

vernacular to identify expectations with other key actors.[9] Arms control is a term which governments use as a broad diplomatic tool to implement threat reduction measures and balance arms parity. Jeffrey Larsen's *Historical Dictionary of Arms Control and Disarmament* defines arms control as an effort to "apply restraints and limits on forces," which includes measures "intended to reduce the likelihood of war, to limit the costs of preparing for war, and should war occur, to reduce the consequences."[10] The degree in which arms control is applied depends on mutual agreements of priorities and objectives. John D. Maurer argues that the ultimate purpose of arms control will truly dictate how the end goals of arms control—disarmament, stability, and advantage—unfold.[11] Both the United States and Russia have differing objectives on attaining strategic stability. An advantage to one party is destabilizing for the other, and vice-versa. As such, it is imperative that all parties involved have a clear understanding of what results are to be achieved so as to make realistic agreements.

An *arms reduction* method is as its name suggests—a reduction in the number of arms a state actor possesses and utilizes. An example of this type of policy is the bilateral New START, which seeks the aggregate reduction of strategic arms from deployed Intercontinental Ballistic Missiles (ICBMs), submarine-launched ballistic missiles (SLBMs) and nuclear-capable heavy bombers to 1,550 nuclear warheads.[12] New START can largely be attributed to the intent outlined in the 2010 NPR and the nuclear security agenda from the Obama administration. The prevailing theme was "reducing nuclear dangers" while maintaining "stability at reduced nuclear force levels."[13]

Disarmament supports the destruction and/or reduction of certain weapons and their associated systems. The INF Treaty can be categorized as a disarmament measure, as it called for the destruction of all U.S. and Soviet ground-launched ballistic missiles (GLBMs) and GLCMs that ranged between 500 and 5,500 kilometers, as well as the associated support structures.[14] NATO's fielding of the Pershing II (GLBM) and the GLCMs was arranged to offset the Soviet Union's deployed SS-20, SS-4, SS-5, SS-12, and SS-23 IRBMs as a counterstrategy to maintain parity.[15] As the Soviet Union became increasingly open to Western principles in hopes of reviving the communistic government, Gorbachev agreed to the terms of the INF Treaty, largely to alleviate the economic burden of massive military expenditures that plagued the crippling Soviet economy. Gorbachev linked the massive defense expenditures of the Brezhnev-era Cold War policies to the plummeting economy and thus sought measures to reduce defense spending.

In terms of arms control, the end of the Cold War culminated in IRBM and GLCM dismantlement. However, it is important to note that current policy decisions indicate that both the United States and Russia do not view disarmament as a near-term end goal of arms control. For the United States, the impetus behind this is the long-term modernization goals of the nuclear arsenal. This modernization

9. In international relations academia, an actor is an entity (e.g., governments, individuals, corporations, groups) that can affect the political environment. This further breaks down into state actors and non-state actors.
10. Jeffrey A. Larsen and James M. Smith, *Historical Dictionary of Arms Control and Disarmament* (Lanham, MD: Scarecrow Press, 2005): 23.
11. John D. Maurer, "The Purposes of Arms Control," *Texas National Security Review* 2, no. 1 (November 2018): 10. https://tnsr.org/2018/11/the-purposes-of-arms-control/
12. "Treaty between the United States of America and the Russian Federation on Measures for the Further Reduction and Limitation of Strategic Offensive Arms." U.S. Department of State, April 8, 2010, https://www.state.gov/documents/organization/140035.pdf.
13. U.S. Department of Defense, *2010 Nuclear Posture Review* (Washington, D.C.: U.S. Department of Defense, 2010): 19, https://dod.defense.gov/Portals/1/features/defenseReviews/NPR/2010_Nuclear_Posture_Review_Report.pdf.
14. This equipment included support structures, support equipment associated with such missiles, and launchers. See Article X of the "INF Treaty," https://www.state.gov/t/avc/trty/102360.htm#text.
15. Ulrich Kühn and Anna Péczeli, "Russia, NATO, and the INF Treaty," *Strategic Studies Quarterly* 11, no. 1 (Spring 2017): 83, https://www.jstor.org/stable/10.2307/26271591.

is a high priority for the Department of Defense, and therefore it is reasonable to suggest that disarmament is not currently an end goal. The 2018 NPR announced long-term defense plans to upgrade all three legs of the triad: the *Columbia*-class SSBNs are set to replace the *Ohio*-class SSBNs (2031), the current U.S. ICBM Minuteman III will be replaced with the completely redesigned Ground-Based Strategic Deterrent (GBSD) (late 2020s) and the strategic bombers and air-delivered weapons are set to be modernized along with the employment of the next-generation B-21 Raider bomber aircraft (mid-2020s).[16] These strategic nuclear assets will be operationally utilized for many decades to come, standing in contradiction to the Non-Proliferation Treaty's "good faith on effective measures" in nuclear disarmament, which is arguably not an urgent objective in the near future.[17] Furthermore, Russia also does not view disarmament as an end goal of arms control. The very nature of their nuclear policy is a stalwart in military objectives to promote international clout. This paper will further address the Russian perspective in later paragraphs.

INF TREATY'S DEMISE

In July 2014, just several months after Russia's annexation of Crimea, the United States openly accused Russia of illegal flight testing of the SSC-8,[18],[19] a GLCM strictly prohibited by the INF Treaty—one that has the range to strike much of Europe. For the first time, the Department of State's 2014 treaty compliance report asserted its findings that Russia was in violation of the INF Treaty.[20] Since then, the United States has condemned noncompliance coupled with economic sanctions; however, the massive monetary loss did not change Russia's behavior.[21] The 2016 treaty compliance report activated INF's Special Verification Council (SVC) to reconvene in order to determine technical compliance.[22] In March 2017, General Paul Selva, the vice chairman of the Joint Chiefs of Staff, confirmed to Congress that the Russians deployed a land-based cruise missile system. More recently, NATO and Russia formally engaged the issue in Brussels, but the meeting culminated with Russian denial of noncompliance, much to the chagrin of NATO. This response further reinforced the lack of Russian transparency or acknowledgment in arms control measures. Conversely, Russia has argued that the United States has been in violation of INF with the deployment of the Aegis Ashore and its abilities to employ a Tomahawk cruise missile.[23]

In February 2019, U.S. secretary of state Mike Pompeo formally announced that the United States would suspend its obligations to the Reagan-era treaty due to the Russian breach of treaty terms

16. 2018 NPR, 49.
17. Article VI of the Non-Proliferation Treaty states that "Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control."
18. During the experimentation and testing phase, the experimental designation was known as the "SSC-X-8." Once Russia operationally deployed the missile, the designation became "SSC-8" by U.S. intelligence reports.
19. The Russian Federation designation for this missile system is 9M729.
20. U.S. Department of State, *Adherence To and Compliance With Arms Control, Nonproliferation, and Disarmament Agreements and Commitments* (Washington, DC: U.S. Department of State, 2014), https://2009-2017.state.gov/t/avc/rls/rpt/2014/230047.htm.
21. Joe Gould, "U.S. Lawmakers Urge Obama to Punish Russia Over Missile Treaty Breach," *Defense News*, October 19, 2016, http://www.defensenews.com/articles/us-lawmakers-urge-obama-to-punish-russia-missile-treaty-breach.
22. The on-site inspection regime concluded on May 31, 2001—13 years following the Treaty's entry into force. All inspection activities have now ceased in accordance with the provisions of the Treaty. Since 2001, the verification regime has been active through National Technical Means (NTM).
23. According to the United States, the Aegis Ashore does not have offensive capabilities and incorporates an interceptor missile (SM-3) that is designed to "solely intercept and counter objects not located on the surface of the Earth." See "Bureau of Arms Control, Verification and Compliance Factsheet - Refuting Russian Allegations of U.S. Noncompliance with the INF Treaty," U.S. Department of State, December 8, 2017, https://www.state.gov/t/avc/rls/2017/276360.htm.

in order to "defend U.S. national security and interests and those of our allies and partners."[24], [25] NATO issued a statement displaying unwavering support in the decision for withdrawal, but not without adamant calls urging Russia to return to "full and verifiable compliance" before the end of the six-month countdown for complete dismantlement. The Kremlin swiftly responded just one day after the announcement, with Russian president Vladimir Putin asserting that there would be "countermeasures [. . .] at those facilities which we think pose a threat to us."[26] This threat reminds the international community that Russia will retaliate against NATO forces if its security interests are threatened. Russia has military and political advantages by withdrawing from INF. From a Russian perspective, the lack of treaty obligation of neighboring regional powers (i.e., India, Pakistan, and China) consents to security weakness and it will not accept an agreement that would degrade Russian military prowess or threaten national interests. With the dissolution of this bilateral treaty, unfettered missile proliferation across the European theatre could lead to escalated tensions between NATO and Russia if missiles are prevalent.

Critics of the INF Treaty posit that it places the United States at an unfair disadvantage and constrains flexibility in security measures. Despite these critiques, the treaty displayed a globally strategic message that codified the importance of arms control.

RUSSIAN PERSPECTIVE

Since the start of the Cold War, nuclear weapons have been central to Russia's political and military identity. Historically, doctrine regarding nuclear weapons has evolved over time, yet the parameters for use remain convoluted. In 1982, Leonid Brezhnev pledged a No First-Use (NFU) policy, stating that the use of nuclear weapons would be strictly retaliatory. This NFU declaratory policy surfaced around the same time as the Nuclear Freeze Movement's global prominence in an effort to "stop the drift toward nuclear war through a U.S.-Soviet agreement to stop the testing, production, and deployment of nuclear weapons."[27] From this angle, the Soviets appeared as if they were exercising nuclear restraint. However, the U.S. and NATO leaders viewed this as deceptive propaganda, reinforcing the incredulous perception of their nuclear policy intent. After the fall of the Soviet Union, Boris Yeltsin reversed their NFU policy (1993), formalizing the intent of nuclear weapons use and emphasizing that there were no "specific missions to nuclear weapons" and therefore did not define any threats to which "nuclear weapons were supposed to respond," which messaged an ambiguous nuclear agenda.[28] Furthermore, Vladimir Putin's military doctrine (2014) reinforced Russia's right to use nuclear weapons in response to an in-kind attack as well as in response to "aggression against the Russian Federation with the use of conventional weapons when the very existence of the state is in jeopardy."[29] This evolution developed as a result of NATO's strong conventional forces—a conflict in which Russia could not defeat without the use of its nuclear weapons. The reliance of nuclear

24. "Remarks: Secretary of State Mike Pompeo," U.S. Department of State, https://www.state.gov/secretary/remarks/2019/02/288722.htm.
25. U.S. officials cited withdrawal from under XV of the INF Treaty, which states, "Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests." The Trump administration asserted that Russia's noncompliance is a threat to U.S. security interests in Europe.
26. Vladimir Putin, "Presidential Address to Federal Assembly" (address, Gostiny Dvor, Moscow, Russia, February 20, 2019), http://en.kremlin.ru/events/president/news/59863.
27. Lawrence S. Wittner, "The Nuclear Freeze and It's Impact," *Arms Control Today*, https://www.armscontrol.org/act/2010_12/LookingBack.
28. "The Basic Provisions of the Military Doctrine of the Russian Federation," *Krasnaya Zvezda*, November 19, 1993.
29. "The Military Doctrine of the Russian Federation," *Nezavisimaya Gazeta*, December 25, 2014, https://rusemb.org.uk/press/2029.

weapons is at the core of its military doctrine; that flexibility allows for an array of strategic military options, bolstering its core deterrence calculus.

Given current international politics, the INF Treaty's importance in Europe is rooted in the prevention of an arms escalation race that could create regional instability due to Russia's conditional thresholds regarding nuclear weapons use, even in a limited war. Nuclear weapons are regarded as the most "important means of assuring military security simply because Russian non-nuclear forces are not seen as effective enough to counter the U.S. or China's conventional forces."[30] Heavy reliance on their nuclear arsenal remains a central military strategy; therefore, propagating nuclear-tipped intermediate-range missiles would reinforce Russia's military objectives and core deterrence in light of a threatening NATO force. Russia's power projection thrives on its military muscle, rendering its nuclear arsenal particularly effective. This further reinforces the importance of constructing viable alternatives to the INF Treaty in order for Russia to believe parity has been achieved, thus promoting stability.

Furthermore, Russia favors nuclear brinksmanship. Although this policy is not clearly defined, its military exercises and ambiguous nuclear threshold indicate this approach. Because conventional NATO forces have a clear numerical and technological advantage over Russia in a direct conflict, Russia has planned "for the use of nuclear weapons early in a crisis."[31] This concept is not explicitly outlined in their military doctrine; however, in practice their military training exercises have suggested their strategies align to this idea. Russian strategic exercises such as ZAPAD and VOSTOK reinforce their willingness for a limited use of nuclear weapons in a conflict in order to mitigate superior conventional force incidents or even perceived threats. After the 2008 invasion of Georgia and the 2014 invasion of Ukraine, Putin made a threat to the West and stated, "we are hoping that our partners will [. . .] remember what discord between large nuclear powers can do to strategic stability."[32] Putin's threats placed the West into a position of possibly facing off against Russian nuclear capabilities if it conventionally intervened in these two conflicts. Unsure of Putin's escalation intentions, the West chose nonmilitary intervention to Russia's annexation of Ukrainian territory.[33]

While the United States possesses a strategic triad nuclear force, Vladimir Putin also enjoys a "wide range of options on the nuclear escalation ladder."[34] Russia's hard power relies on its strong nuclear and conventional military muscle to maintain international leverage and guarantee power. Vladimir Putin has asserted that "everything we do is just a response to the threats emerging against us."[35] The reasons behind the Russian treaty violations indicate that there is no incentive to continue compliance. He has stated that other nations should "assume the same level of obligation," and that if the same obligations are precluded, then "it will be difficult for us to keep within the framework of the treaty in a situation where other countries do develop such weapon systems, and among those are countries located in our near vicinity."[36] The utility of NATO's defense and deterrence postures

30. Yury E. Fedorov, "Russia's Nuclear Policy," in *Major Powers' Nuclear Policies and International Order in the 21st Century*, ed. Boeicho Boel Kenkyujo (Tokyo: National Institute for Defense Studies, 2010).
31. Matthew Kroenig, "Facing Reality: Getting NATO Ready for a New Cold War," *Survival* 57, no. 1 (Feb-Mar 2015): 53.
32. Ibid.
33. Since Ukraine is not a NATO member, Article V could not be invoked for collective security. Additionally, the Obama administration did not perceive a U.S. military response as appropriate for the Russian invasion of Crimea, as it could have possibly led to an unwanted nuclear escalation or a preemptive use. See Federov, "Russia's Nuclear Policy," 56.
34. Kroenig, 56.
35. "Russia Would Attack NATO only in Mad Person's Dream'–Putin," RT News, June 6, 2015, http://www.rt.com/news/265399-putin-nato-europe-ukraine-italy/.
36. "Putin Demands INF Treaty Expansion," Nuclear Threat Initiative, October 12, 2007, https://www.nti.org/gsn/article/putin-demands-inf-treaty-expansion/.

causes Russia to maintain its vigilance on any tactical and strategic measures along with its attempts to counter and discredit the efficacy of the NATO alliance.

CURRENT U.S. AND NATO DEFENSE/DETERRENCE POSTURES

The current U.S. and NATO missile defense system in Europe is very reliant on the Aegis Ballistic Missile Defense (BMD) system. Under the Obama administration, a European Phased Adaptive Approach (EPAA) was established to enable a phased upgrade to land-based missile defense systems in Europe to defend NATO countries and the United States. The EPAA is centered on the U.S. Navy's advanced Aegis Ashore BMD System, consisting of the AN/SPY-1 radar sensor; the Mark 41 Vertical Launch System (VLS); and the SM-3 missile interceptor, positioned in Spain (2011), Romania (2016), and Poland (2020).[37] Additionally, there are 33 sea-based Aegis BMD ships, with 17 assigned to the Pacific Fleet and 16 assigned to the Atlantic Fleet.[38] In addition to the missile defense systems, the United States has reinforced power projection through unified training with NATO allies. In March 2019, the United States positioned a fleet of U.S. B-52 Stratofortress nuclear-capable bombers for training exercises with Norwegian F-16 fighter jets around the Norwegian and Baltic Seas in an effort to "demonstrate U.S. commitment to allies and partners through the global employment of military forces."[39] This B-52 bomber fleet is based out of RAF Fairford, England, in which the training exercises maintain a heightened state of alert readiness to support deterrence and substantiate a continuous bomber presence and global strike capabilities. In May 2019, nine NATO nations—including the United States—participated in Exercise *Formidable Shield*, in which the training coalition conducted live-fire missile defense drills and practiced NATO command and control procedures and interoperability.[40] Furthermore, a proposal to establish a U.S. base in Poland highlights the steadfast security of NATO and geostrategic positioning of Allied forces. Polish president Andrzej Duda stated that there is a "clear and present need for a permanent U.S. armored division deployed in Poland."[41] In August 2019, the Pentagon tested a Tomahawk cruise missile (TLAM) from a Mk 41 VLS on land, a test which would have been prohibited under INF.[42] The United States and NATO are maintaining a united front through force posturing and multilateral power projection.

MOVING FORWARD POST-INF

As both nations shift away from the INF Treaty, the United States should be prepared for how Russia will change the employment of their intermediate-range missiles by enacting three measures:

- Reinforce a unified front with the NATO alliance
- Organize a multilateral hypersonic weapons treaty
- Establish bilateral compromises through diplomacy

37. Ian Williams, "Aegis Ashore," *Missile Threat*, Center for Strategic and International Studies, April 14, 2016, last modified June 15, 2018, https://missilethreat.csis.org/defsys/aegis-ashore/.
38. "Aegis Ballistic Missile Defense," Missile Defense Agency, https://www.mda.mil/system/aegis_bmd.html.
39. "U.S. Air Force B-52s Conduct Missions Across Europe," U.S. Air Force Press Release, March 19, 2019, https://www.usafe.af.mil/News/Press-Releases/Article/1788427/us-air-force-b-52s-conduct-missions-across-europe/.
40. "NATO ships start missile defence drill off Scotland," North Atlantic Treaty Organization, May 8, 2019, https://www.nato.int/cps/en/natohq/news_165940.htm.
41. Michael A. Hunzeker and Alexander Lanoszka, "The Case for a Permanent U.S. Military Presence in Poland," *War on the Rocks*. October 22, 2018, https://warontherocks.com/2018/10/the-case-for-a-permanent-u-s-military-presence-in-poland/.
42. Sebastian Roblin, "Pentagon Dashes Inyo Post-INF Arms Race with Tomahawk Missile Test Certain to Anger Moscow," *Forbes*, August 21, 2019, https://www.forbes.com/sites/sebastienroblin/2019/08/21/pentagon-dashes-into-post-inf-arms-race-with-tomahawk-missile-test-certain-to-anger-moscow/#57c986ef7b9d.

REINFORCE FRONT WITH NATO ALLIANCE

Strengthening NATO's cohesion and unity is vital to bolster deterrence against Russia's unfettered intermediate-range missile use and deployment. In the contemporary world, collective security is essential. The United States should remain unconditionally devoted to NATO's core mission and reinforce the legitimacy of Article V. Since NATO's Secretary-General Jens Stoltenberg has stated that they do not plan on deploying new land-based nuclear missiles in Europe, [43] which is a popular sentiment in NATO, the United States should fully support the NATO decision and remain unified. The Fiscal Year (FY) 2020 defense budget requested $14.6 billion for missile defense systems to ensure technological advantages based on the 2019 Missile Defense Review.[44] However, currently there are no nations willing to host these U.S. missiles in Europe or other regions such as Australia. With an increase in allocation for missile defense, the United States should remain cognizant of NATO intentions for hosting certain missile defense systems or intermediate-range missiles and be willing to enact alternative methods for basing weapons, such as U.S. Navy-based weapons on international waters. A unified front will help solidify the credible deterrence against Russian aggression.

ORGANIZE TREATY TO ADDRESS HYPERSONIC WEAPONS

The hypersonic (cruise missiles and glide vehicles) weapons development and research is a high priority for Russia, China, and the United States. For the United States, these weapons offer another powerful military tool in order to deter adversaries, reassure allies, and maintain a competitive advantage. However, with INF absent, Russia has the international freedom to deploy hypersonic technologies with intermediate-range missiles. The utility of these weapons is that they are highly maneuverable and rapid (Mach 5+) and have the capability of delivering mass destruction to high-value targets without leaving the atmosphere, creating unpredictability for incoming targets. The deployment and usage of internationally unregulated hypersonic weapons raise a plethora of concerns in determining an adversary's strategic deterrence calculus. Although a multilateral treaty geared towards limiting the development and/or employment of hypersonic weapons may be unlikely at the research and development stage, initiating diplomatic talks towards a treaty is a means to help control the arms control narrative and hopefully build upon arms control stability in this evolving area. The United States does not currently have defenses to counter hypersonic weapons, but neither does Russia or China. In this position, a multilateral treaty on hypersonic weapons with all three nations could benefit from an arms production limitation. Joseph Nye Jr. suggests that arms control agreements are effective only when "neither side has an appreciable advantage."[45] If the treaty would be fair and equitable to all signatories, then the probability of negotiations would be more likely.

ESTABLISH COMPROMISE THROUGH DIPLOMACY

The complexity in compromise lies in the dichotomy between maintaining parity (stability) while strategically using arms control to bolster national interests (advantage). There is intrinsic value in compromise that leads to some degree of success. It is commonly utilized as a political tool as it postulates a baseline to promote parity through mutual cooperation. As both parties agree to arms

43. Steven Erlanger, "End of Missile Treaty Leaves a Major Vacuum in NATO Defense," *The New York Times*, August 2, 2019, https://www.nytimes.com/2019/08/02/world/europe/inf-treaty-nato-russia.html.
44. Office of the Undersecretary of Defense, Comptroller/Chief Financial Officer, *Defense Budget Overview* (Washington, DC: U.S. Department of Defense, 2019), https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2020/fy2020_Budget_Request_Overview_Book.pdf.
45. Joseph S. Nye Jr., "Arms Control After the Cold War," *Foreign Affairs* 68, no. 5 (1989): 44.

control terms, theoretically there should be some level of parity due to common constraints. Carnegie fellow Pranay Vaddi suggests that mutually beneficial communication and the implementation of "soft" arms control agreements may possibly be the way ahead in the arms control realm.[46] Communication is key, yet therein lies the problem of Russia's violations of the INF Treaty. The United States asserts that the Russians' blatant disregard of the terms makes it unfavorable for the United States to remain obligated to abide by its terms.

It would be naive to assert that compromise is a simple notion to achieve. The reality is that the most powerful variables in the compromise equation are political figures and their agendas, as they invariably shape international policy. For example, Donald Trump and Vladimir Putin have divergent perspectives and agendas than that of Reagan and Gorbachev in 1986. For political leaders that operate primarily on realist principles, it is noteworthy to dissect the motivating factors of these individuals to achieve the arms control security blanket.

Vladimir Putin asserted that Russia inherited a security disadvantage with the INF Treaty, which answers why Russia initially violated the treaty. Russian security threats and, conversely, their interests are indicative of their likelihood to comprise on arms control policies. Understandably, these two actors have respective security concerns. From the U.S. perspective, it is worrisome to European stability and NATO's assurance. To address these concerns from both parties, more flexibility with fewer constraints in agreements could allay security fears. For example, instead of a complete arms dismantlement of intermediate-range missiles, there could be an established bilateral agreement for a *limited* number of deployed IRBMs in the region. This compromise could satisfy both parties' gripes with INF (China's unregulated arsenal), while still maintaining arms control in Europe. China has not shown interest in arms control agreements and will reject a multilateral agreement. This idea would sustain arms control, but under the guise of arms *reductions* versus an arms *dismantlement*. Although not ideal for disarmament goals, this compromise could aid in increased stability. Russia desires parity, especially with a NATO threat from the West and China from the East. To satisfy their approach to maintain a strategic advantage, it is important to note what Russia hopes to gain from arms control. This can aid the United States in constructing effective agreements, such as a reduction in missile defense interceptors or early warning radars.

CONCLUSION

The future of European arms control will remain in question until the United States leads the charge in the next courses of action. The INF Treaty proved to be a stabilizing force even after the end of the Cold War but unfortunately was seen as a Cold War relic by the United States and Russia. With time, a complete withdrawal from INF without reasonable alternatives will inevitably lead to an emerging instability crisis. The INF Treaty is not salvageable as both the United State and Russia are operating on differing political and military logic; however, there are options that can help mitigate a renewed arms race and would lead to increased instability. By reinforcing a unified front with the NATO alliance, organizing a multilateral hypersonic weapons treaty, and establishing bilateral compromises through diplomacy are reasonable approaches in this post-INF environment. As the United States and its NATO allies navigate how to move forward, these approaches will help create increased arms control stability and establish confidence-building measures. The United States should consider arms control to be the priority.

46. Pranay Vaddi, Lecture, Center for Strategic International Studies, Washington D.C., March 16, 2019.

Expanding Cyber Resilience Beyond Convention

Resiliency and Nuclear Command, Control, and Communications

Rick Cassleman[1]

ABSTRACT

Implementing cyber resilience is vital to the nuclear enterprise. This paper addresses the challenges to implementing cyber resilience in nuclear networks like NC3, including conceptual differences between nuclear operations and cyber operations, upcoming modernization initiatives, and Advanced Persistent Threats. Ways to overcome these difficulties are presented, including concrete resiliency techniques and discussions on artificial intelligence (AI). There are potential benefits from cyber resilient nuclear communication systems, including increased situational awareness and reduced miscalculation. Finally, there are still several unanswered questions that arise for the nuclear enterprise in an age of increased reliance on networks and technological advancement.

INTRODUCTION

The fact that the greatest value of all of the weapons of massive retaliation lies in their ability to deter war does not diminish their importance, nor will national security in the years ahead be achieved simply by piling up bigger bombs or burying our missiles under bigger loads of concrete. For in an imperfect world where human folly has been the rule and not the exception, the surest way to bring on the war that can never happen is to sit back and assure ourselves it will not happen. The existence of mutual nuclear deterrents cannot be shrugged off as stalemate, for our national security

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in a period of rapid change will depend on constant reappraisal of our present doctrines, on alertness to new developments, on imagination and resourcefulness and new ideas.[2]

These remarks from President John F. Kennedy to the graduating class of 1963 at the U.S. Air Force Academy continue to ring true today. Nuclear weapon systems cannot be taken for granted; in periods of rapid change and new developments like the present period, constant reappraisal of doctrines is necessary. Cyberspace did not exist during Kennedy's presidency, yet his words incorporate the growing changes in the cyber realm and their application to the U.S. nuclear enterprise. This paper attempts to address "alertness to new developments" in cyberspace, specifically the recent discussion of cyber resiliency and its application to nuclear systems.

Numerous outlets over the last decade, including the Department of Defense (DoD), have highlighted cyberspace and the protection of its cyber assets as paramount. Much of this discussion focuses on the prevention of cyberattacks; defense against an attack is key for cybersecurity. This paper argues that a more robust view of cybersecurity is needed for the protection of military networks, most notably nuclear networks. The DoD has opened the door for cyber resilience in its networks in the last several years; this concept means that a network has the ability to quickly return to a minimum level of operability. This paper addresses the need for cyber resiliency in nuclear command and control systems and the DoD's growing awareness of this need; as modernization of nuclear systems approaches, cyber resiliency plays a key role. Challenges to cyber resilience are discussed along with concrete solutions that can be implemented now; AI is also mentioned as a potential answer for the future, though not without its cautions. Benefits to the nuclear enterprise from cyber-resilient systems include increased situational awareness and strategic stability, although there are still lingering questions for resilience and nuclear networks as threats adapt and grow. Overall, implementing cyber resilience is imperative to the nuclear enterprise. As cyber threats against the United States and in particular the nuclear enterprise continue to expand, investment in durable cyber resilience will hedge against rising challenges.

NETWORK DEFENSE, CYBERSECURITY AND CYBER RESILIENCE

Cybersecurity has received increased attention across the government, academia, and the private sector in recent years as reliance on networks and technology has continued to increase. The pillars of cybersecurity have traditionally formed the trio of confidentiality, integrity, and availability (CIA).[3] Confidentiality refers to restricting access to only those who should have access. Integrity refers to information and data being accurate and only edited by those authorized. Availability means that, upon legitimate request, those with access actually have data available to them. A loosely protected network will have strong availability but potentially weak confidentiality; likewise, an extremely hardened network will have strong confidentiality but could be overly cumbersome to access for regular users.

Among the various elements within cybersecurity is network defense. While network defense has been a focus for the past decade, organizations have recently taken a more holistic view of cybersecurity that includes cyber resilience. While network defense and cyber resilience work closely with each other and are extremely interrelated, they occupy different places in a cyber regime. The

2. John F. Kennedy, "Remarks at U.S. Air Force Academy, Colorado Springs, Colorado, 5 June 1963," John F. Kennedy Presidential Library and Museum, https://www.jfklibrary.org/asset-viewer/archives/JFKPOF/044/JFKPOF-044-035.
3. "EI-ISAC Cybersecurity Spotlight – CIA Triad," Center for Internet Security, https://www.cisecurity.org/spotlight/ei-isac-cybersecurity-spotlight-cia-triad.

network defense portion of cybersecurity focuses on preventing an attack; it "protects the data and integrity of computing assets belonging to or connecting to an organization's network. Its purpose is to defend those assets against all threat actors throughout the entire life cycle of a cyberattack."[4]

Resilience, on the other hand, refers to "the system's ability to recover or regenerate its performance to a sufficient level after an unexpected impact produces a degradation of its performance. It is characterized by [four] abilities: to plan/prepare, absorb, recover from, and adapt to known and unknown threats."[5] The National Institute of Standards and Technology (NIST) defines cyber resilience as "the ability to anticipate, withstand, recover from, and adapt to adverse conditions, stresses, attacks, or compromises on systems that use or are enabled by cyber resources regardless of the source."[6] Cyber resilience can mean operating during an attack and achieving a minimum level of operational ability while responding to any breach. Resiliency also includes not just the networks themselves but systems that rely on cyber resources somewhere in their life cycle, increasing the scope of cyber protection.

In terms of definitions, it is understood that cybersecurity and cyber resiliency overlap in a number of areas. To highlight the diverse elements within cybersecurity, network defense is the term used that describes the prevention of intrusion and network hardening. This is contrasted with the development of resilience, which construes the ability to bounce back from attacks, reworking existing pathways and future developments to foster more flexibility. The terms cybersecurity and cyber protection are used when including both concepts of defense and resilience. Sometimes cybersecurity has been used with an emphasis on prevention of cyberattacks and network defense, though more recent uses of the term include the concept of resilience, evident in FireEye's emphasis on cybersecurity "throughout the entire life cycle of a cyberattack."

CYBER RESILIENCE IN THE NUCLEAR ENTERPRISE

There is a growing awareness of cyber threats within the Department of Defense and the nuclear community. Furthermore, cyber resilience is necessary in any overarching approach to the cyber protection of Nuclear Command, Control, and Communications (NC3) and other like components. The Nuclear Posture Review (NPR) of 2018 says "in light of the critical need to ensure our NC3 system remains survivable and effective, the United States will pursue a series of initiatives [including] strengthening protection against cyber threats."[7] By its very nature, NC3 must be survivable; survivability and resilience go hand-in-hand as cyber resiliency helps ensure survivable components are still useable after a cyberattack. NC3, "while once state-of-the-art, [is] now subject to challenges from both aging system components and new, growing 21st century threats. Of particular concern are expanding threats in space and cyber space."[8] These quotes make clear that cyber threats against NC3 are principal among the long list of concerns in the NPR. The NPR specifically addresses offensive cyber threats by stating:

4. "What is Cyber Security," FireEye, https://www.fireeye.com/current-threats/what-is-cyber-security.html.
5. Alexander Kott et al., *Approaches to Enhancing Cyber Resilience: Report of the North Atlantic Treaty Organization (NATO) Workshop IST-153*, (Adelphi, MD: U.S. Army Research Lab, April 2018) 8-9, https://www.arl.army.mil/arlreports/2018/ARL-SR-0396.pdf.
6. National Institute of Standards and Technology, *Systems Security Engineering: Cyber Resiliency Considerations for the Engineering of Trustworthy Secure Systems, Draft NIST Special Publication 800-160*, (Gaithersburg, MD: National Institute of Standards and Technology, March 2018) 1, https://csrc.nist.gov/CSRC/media/Publications/sp/800-160/vol-2/draft/documents/sp800-160-vol2-draft.pdf.
7. Office of Secretary of Defense, Nuclear Posture Review (Washington, DC: U.S. Department of Defense, February 2018) 18, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF
8. Ibid., 23.

> The emergence of offensive cyber warfare capabilities has created new challenges and potential vulnerabilities for the NC3 system. Potential adversaries are expending considerable effort to design and use cyber weapons against networked systems. While our NC3 system today remains assured and effective, we are taking steps to address challenges to network defense, authentication, data integrity, and secure, assured, and reliable information flow across a resilient NC3 network.[9]

In this quote, the review lucidly speaks to CIA and network defense while leaving room for focus on cyber resilience in NC3.

Quoting the Department of Defense's Defense Science Board in their 2017 *Task Force on Cyber Deterrence*, they state, "in effect, [the] DoD must create a second-strike cyber resilient 'Thin Line' element of U.S. military forces to underwrite deterrence of major attacks by major powers." Later, it says that the Secretary of Defense needs to "immediately direct Commander USSTRATCOM to conduct an annual assessment of the cyber resilience of the U.S. nuclear deterrent including all essential nuclear 'Thin Line' components (e.g., NC3, platforms, delivery systems, and warheads)."[10] These quotes underscore the growing awareness of cyber resiliency as a foremost necessity in NC3, nuclear operations, and the weapons systems themselves.

BROADENING RESILIENCE

A NECESSITY FOR NUCLEAR MODERNIZATION

Shifting from a mindset of awareness to a focus on implementing resilience in nuclear networks, the current concept of resilience present in nuclear systems can be organically built upon to include not just resilience against conventional or nuclear kinetic attacks, but also cyberattacks. Furthermore, this expansion is a necessity as modernization progresses and nuclear components are renovated. Resilience, more broadly, has been part of producing a reliable and survivable NC3 network since the beginning of its development. One area this is demonstrated in is the "thick-line" and "thin-line" of nuclear communications, where there is a complement of immediate and continuous access to the president alongside an enduring and survivable network to the president and DoD decisionmakers.[11] The focus on redundancy, survivability, reliability, and continuous access demonstrates secure processes and great resilience in the system; the resiliency already present in the network's architecture is a natural foundation for expansion to cyber resiliency amidst modernization. This is needed as even the *Nuclear Matters Handbook* produced by the Office of the Deputy Assistant Secretary of Defense for Nuclear Matters acknowledges the tension between the need for modern equipment to operate on "internet-like networks" and the resulting "implications and applicability of this policy [introducing] increased vulnerability."[12]

Implementing cyber resiliency in network processes and architecture is the first step to alleviate concerns with modernization as components age and technological advancements are incorporated into systems like NC3. While processes and architecture in cyber systems can appear complex and abstract, a concrete example will help elucidate the issue. NIST argues for separating out life

9. Ibid., 57.
10. Defense Science Board, *Task Force on Cyber Deterrence* (Washington, DC: U.S. Department of Defense, February 2017) 17, 24, https://fas.org/irp/agency/dod/dsb/cyber-deter.pdf.
11. Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, *Nuclear Matters Handbook* (Washington, DC: U.S. Department of Defense, March 2017) 81, https://www.acq.osd.mil/ncbdp/nm/NMHB/docs/NMHB_2016-optimized.pdf.
12. Ibid., 81.

cycle stages in cyber resilience; the first three stages are concept, development, and production.[13] A unifying theme in this discussion is a focus on tailoring objectives and design principles throughout these initial stages. Clarifying what objectives are truly primary for a system helps direct the most effective processes and lays the most resilient foundation for the future as the hardware and software built around a given system will most directly relate to its mission objectives. So, for example, the "thin-line" of NC3 as previously mentioned is meant to provide survivable and enduring communication to top decisionmakers. When designing the future modernization upgrades to these communication systems, using this objective as the starting point frames the parameters for subsequent hardware and software upgrades, with the ultimate goal of allowing for more efficient and streamlined responses during cyberattacks. This example demonstrates the priority of resiliency in processes and architecture in their foundation so as to buffer against unknown threats.

Protecting the supply chain to nuclear-related systems is another pressing issue in which the implementation of cyber resilience could help, though it is a two-fold issue. Expanding cyber resiliency to DoD-owned networks helps assuage cyber protection concerns with the supply chain, yet cyber resiliency also faces unique challenges from deficiencies in the supply chain. Furthermore, while traditionally the threats to the nuclear enterprise have been kinetic in nature, the notion of a cyber threat is much broader and must cause the United States to think beyond traditional military targets. The military goes to great lengths to harden communication networks and the hardware components within operations centers or weapons systems; this has been the focus of the last several decades in nuclear surety (i.e., providing reliable use of nuclear weapons and keeping them safe when not in use).[14] Yet the supporting infrastructure to those communication lines, weapons systems, or operations centers may not be as reliable or secure since they could be run by a city or civilian organization.[15] The NPR alludes to this in its discussion of modernization and the need to "ensure the continuing availability of U.S.-produced information technology necessary for the NC3 system."[16] The DoD's *Cyber Strategy 2018* also emphasizes this point asserting:

> The Department must be prepared to defend non-DoD-owned Defense Critical Infrastructure (DCI) and Defense Industrial Base (DIB) networks and systems. Our chief goal in maintaining an ability to defend DCI is to ensure the infrastructure's continued functionality and ability to support DoD objectives in a contested cyber environment … the Department will: set and enforce standards for cybersecurity, resilience, and reporting; and be prepared, when requested and authorized, to provide direct assistance, including on non-DoD networks, prior to, during, and after an incident.[17]

This paper is not attempting to argue that cyber resilience will solve every issue with the supply chain and "non-DoD-owned DCI." Non-DoD owned infrastructure especially is a thorny problem for the DoD because it is difficult enough to monitor its own logistics notwithstanding sprawling commercial sectors. However, the general concept of cyber resilience is important as a conceptual foundation for components that make up networks like NC3 because the ability to return to normal functioning becomes ever more important as systems become more digital and more network-centric.

13. NIST, *Systems Security Engineering*, 24.
14. Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, Nuclear Matters Handbook, 83.
15. Robert S. Anderson, *Cyber Security and Resilient Systems* (Idaho Falls, ID: Idaho National Laboratory, July 2009), 1-2, https://inldigitallibrary.inl.gov/sites/sti/sti/4311316.pdf.
16. Secretary of Defense, *Nuclear Posture Review*, 58.
17. U.S. Department of Defense, *Cyber Strategy 2018* (Washington, DC: U.S. Department of Defense, September 2018), 3, https://media.defense.gov/2018/Sep/18/2002041658/-1/-1/1/CYBER_STRATEGY_SUMMARY_FINAL.PDF.

For example, the E-6B TACAMO (Take Charge and Move Out) is a modified Boeing 707, which "in its TACAMO role [can] relay presidential nuclear control orders to Navy nuclear submarines and Air Force nuclear missiles and bombers."[18] This is a very important feature of the United States' survivable communications in a post-strike environment and has received hardware and software upgrades throughout its lifespan like every Air Force plane modified from a commercial counterpart. Future replacements of planes like the TACAMO could easily use an existing commercial aircraft in the same fashion as the Boeing 707 did for the E-6. The DoD could control key aspects of its nuclear-related communications; moreover, there is confidence that the DoD will ensure such components have had no opportunities for corruption through its logistical lifespan.

These are just the critical nodes for nuclear communications, however; the use of commercial aircraft inherently introduces reliance on non-DoD-owned infrastructure. The hardware itself would most likely come from across the country or the world. The software upgrades throughout its lifetime would most likely come from a combination of its parent commercial company and the Air Force. Further, the networks that monitor such software upgrades may not be DoD-owned. There are arguments against being too digitally dependent when exploitation of digital systems becomes more likely, like the creation of analog backups. However, one area that is becoming increasingly digitalized is aviation, which relates to both the weapons systems involved in the nuclear enterprise (e.g., bombers) and nuclear communications (e.g., TACAMO). Modern planes also greatly rely upon civilian networks to transmit data such as ADS-B, opening up the scope of civilian influence to levels that are increasingly difficult for the DoD to control. This discussion is in part to highlight the difficulties inherent in the supply chain for NC3 but also to demonstrate that an emphasis on resilience provides a default defense against problems stemming from the above difficulties. Resilience assumes a breach has already occurred. So the issues with the example above involving a commercial aircraft become less specific to commercial aviation and focus more attention on the response to the threat. The more resilient the hardware and software that commercial companies provide to the Air Force, including networks and data-links that interact with other planes and ground stations, the easier it will be to continue operations in the face of cyberattacks on these types of networks.

FURTHER CHALLENGES TO CYBER RESILIENCE IN NUCLEAR SYSTEMS

As demonstrated above, there are challenges that need to be overcome in order to implement cyber resilience in nuclear networks and components; several more areas of concern are presented below. The first challenge is rooted in the definition of cyber resilience and its modeling. There is a tremendous need for the accurate modelling of cyber resilience.[19] Modeling the vulnerabilities and risks for a given cybersecurity event is already difficult enough. Yet adding the further step of modeling a system's ability to respond to an unknown attack makes these predictions very tough to accurately assess. The vocabulary in cyber resilience is newer to the cyber community than network

18. Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, *Nuclear Matters Handbook*, 75.
19. Taken from NIST C*yber Resiliency Considerations for the Engineering of Trustworthy Secure Systems*: "A cyber resiliency model is either behavioral or structural. A behavioral cyber resiliency model represents the behavior of a system (at a given architectural layer or range of layers), to facilitate analysis of the cyber effects of adverse events on systems and on system behavior; system behavior with respect to business or mission performance requirements, including security performance under a variety of adverse conditions; and the effects of cyber resiliency solutions or cyber courses of action. Many cyber resiliency models explicitly represent adversarial behavior. A structural cyber resiliency model identifies where and how, within a system architecture, cyber resiliency techniques and approaches are implemented, or cyber resiliency design principles are applied. Both types of cyber resiliency models support cyber resiliency analysis techniques."

defense, so not everyone agrees on definitions. For example, in 2018, a panel of cyber experts from NATO concluded that "much work remains in understanding the fundamental properties of cyber resilience."[20] Accurate modeling will help elucidate these unknowns. Furthermore, measuring cyber resilience is a bit nebulous until someone has to actually respond to a real attack.[21] In the absence of an actual attack, a truly good model will offer the closest picture of the truth and help organizations understand whether or not a system is resilient. The military could also gain tactical advantages to interleaving intelligence with resiliency modeling. In terms of operations, some argue that "mission modeling should be considered part of Intelligence Preparation of the Battlefield."[22]

The second challenge relates to the fundamentally different natures of the cyber and the nuclear enterprise. The two were born into vastly different worlds historically, technologically, and conceptually; these two worlds are now set for collision as modernization of the nuclear enterprise looms on the horizon. While there was infrastructure in place prior, USCYBERCOM achieved Initial Operational Capability (IOC) in 2010.[23] In contrast, Strategic Air Command was established a year prior to the U.S. Air Force's birth in 1947 and oversaw the production of the 1950s era Boeing B-52 Stratofortress which is still in operation today.[24] Technologically and conceptually, the nuclear world is dated and slow; its operators methodical so as to ensure no mistakes are made with weapons of such catastrophic potential. While this meticulousness reinforces the nuclear surety side of the enterprise, it stands in stark contrast to cyber operations. Cybersecurity and resiliency rely on speed, quick decision making, and the ability to predict attacks and patch vulnerabilities before they are exploited. It is anathema to think of a resilient cyber system and its operators methodically laboring over each step of a dynamic cyber event, most notably in a situation dealing with national assets like nuclear-related systems. While there is still room for balance between surety and speed, as nuclear networks and components are modernized, these tensions will further be exacerbated.

Specifically relating to cyber and the nuclear world is also the need for prodigious human capital. The research and development costs of an accurate model are in some ways priceless for a given system. Yet the modeling is only as useful as those who created it. The people who help create the networks, the security for the networks, and the tests and models that are used in assessing security, risk, and resilience must be toward the top of the talent pool or else the United States risks lagging behind more capable foes. While the DoD recruits excellently talented individuals, it does not recruit as many as it would want and must compete with the civilian sector, including Silicon Valley, for experienced workers.[25] Furthermore, the restrictive nature of the rules governing everything nuclear has the potential to frustrate otherwise willing candidates.

Another challenge to cyber resilience in nuclear systems is the need for accuracy and speed amidst vast amounts of data. Going further than constructing a resilient foundation, one of the most crucial components in a dynamic cyber threat environment is speed; the computers and the humans behind them need to be quick in grasping a given attack and deciding upon the best ways for response. This is a perennial challenge; as technologies advance, the pace of operations quickens. Yet the challenge is further aggravated with the ever-increasing number of threats and amount of data collected.

20. Ibid., 28-29.
21. Kott et al., *Approaches to Enhancing Cyber Resilience*, 28.
22. Ibid., 18.
23. "U.S. Cyber Command History," U.S. Cyber Command, https://www.cybercom.mil/About/History.
24. "History," U.S. Strategic Command, https://www.stratcom.mil/About/History.
25. "Cyber Command Steps Up Recruiting Efforts With Special Hiring Authority," U.S. Department of Defense, June 7, 2018, https://dod.defense.gov/News/Article/Article/1544313/cyber-command-steps-up-recruiting-efforts-with-special-hiring-authority.

Speed and accuracy are extremely important to sift through meaningless or faux data. This leads directly to the last challenge of APTs.

Advanced persistent threats (APTs)—advanced cyber threats that can breach critical systems, establish a presence, and inflict immediate or long-term damage—exacerbate the need for speed and accuracy as they could stealthily gain access to a given network without detection.[26] APTs present variegated shades of ambiguity in responding to an attack. They are not as inherently attributable as other actors that could mount similar far-reaching kinetic attacks. There are reasonable beliefs on general locations of where an attack occurred from; however, there can sometimes be room for hesitancy when determining the organizational identity of the threat (i.e., if they are state-funded, acting separately from a host country, etc.).[27] APTs are not one single group and many pose a continued threat over time, which presents problems for cyber resilience because they have a greater ability to adapt while the United States would attempt to restore operations after an attack.[28] They also have the ability for persistent and continued attacks over long periods of time. These attacks could be more likened to an asymmetric siege from various hidden groups than a single strike from a known enemy, complicating the ability to restore operations while under attack. This is of particular concern for nuclear-related systems since an APT's presence might go unnoticed for long periods of time, presenting unknown vulnerabilities and therefore unknown ways to continue minimum operations for nuclear networks. Breaches such as "zero-day exploits" could occur when an adversary discovers a vulnerability so soon after a program or piece of hardware or software is developed and there is almost no chance at preventing an attack.[29] There is cause to be measured in assessments of resilience; the overreliance on one's capabilities for resilience could unwittingly produce destabilization in the end.

CONCRETE TECHNIQUES FOR CYBER RESILIENCE

In response to the above challenges, it will be useful to first discuss more specific techniques within the cyber world that help foster more resilient networks. To again demonstrate the different dimensions of protection and resiliency, a simple phishing example can be used. Network intrusion defense emphasizes prevention of the phishing attempt through various efforts like network security features that can recognize and block malicious attachments. Resilience operates in the environment where the phishing attempt has at least partially succeeded and involves creating a network that continues to operate even in a degraded state. Concrete ways to make cyber operations more resilient include defensive security features like robust firewalls and encryption to provide intra-network protection. Hot swapping out wholesale components potentially allows for cleaner or faster fixes depending on how bad a component is infected. Redundancy is also key to resilience; one of many steps toward redundancy could include an array of disks, like a RAID 5. This entails multiple hardware components "where there is always a little bit of data on each drive, where any two drives can combine to equal the data of the third drive. This allows continued performance and data security even if one drive goes down."[30]

26. NIST, *Systems Security Engineering*, iv, 2, 6.
27. Mandiant, *APT 1: Exposing One of China's Cyber Espionage Units* (Milpitas, CA: FireEye, February 2013), https://www.fireeye.com/content/dam/fireeye-www/services/pdfs/mandiant-apt1-report.pdf.
28. Ibid.
29. "What is a Zero-Day Exploit?" FireEye, https://www.fireeye.com/current-threats/what-is-a-zero-day-exploit.html.
30. Seneca, "What is Raid and How Can It Protect My Data?," *SenecaBlog*, February 11, 2017, https://www.senecadata.com/raid-can-protect-data/.

Isolating a minimum number of systems and subsystems that can do the given job on different networks promotes resilience too. Setting up these redundant pathways for critical operational needs or even pathways with artificially lowered encryption for critical communications strengthens this approach.[31] Constructing the appropriate node degree of distribution within a network and focusing on the protection or substitution of the most vital nodes promotes resiliency as well. (Nodes here represent connection points for a given network with node degree of distribution relating to the structure of these connections—where and how connections are established and, in terms of resiliency, if those connections are optimized for responding to an attack). For instance, if a network is scale-free and has several dominant nodes that are hubs for other lesser nodes' connectivity then these dominant nodes could be prioritized in protection or hot swaps.[32] A key here would also be preventing cascading faults where a degradation in one node causes a domino effect through various systems or networks. Another way to mitigate these cascading effects is through targeted buffering and broader local access so as to decrease the user's need for centralized hubs in case the centralized nodes are unusable; in effect, this equates to finding ways for the most essential to receive the minimum amount of information necessary for operations.[33] Air gapping is another technique to layer defenses and can promote resilience by providing isolated hardware or networks. Furthermore, layering in several redundant air-gapped networks increases the likelihood of continued operations if one air-gapped network manages to be attacked.

NIST lists fourteen techniques that more broadly promote resiliency within a system along with corresponding technical, concrete examples. Some of the techniques include segmentation, realignment, redundancy, unpredictability, dynamic positioning, diversity, and deception. Segmentation entails isolating components based on mission functions, employing system partitioning, and employing process isolation. Realignment means aligning "system resources with core aspects of organizational missions or business functions." This incorporates prohibiting privileged accounts from non-privileged functions or applications like peer-to-peer music. It also involves trimming the network for mission-essential functions. Unpredictability could involve implementing random channel-hopping on network channels or requiring reauthentication at random intervals. Dynamic positioning entails changing physical locations of components like routers, storage sites, or sensors. Diversity incorporates many concrete examples like using alternate communications protocols, multiple protocol standards, or diverse operating systems when applicable. Deception inherently would be used against the adversary and involves encrypting transmitted data, authenticators, and processing. It also entails disinformation, creating false credentials, using beacon traps, honeypots, and decoys.[34]

U.S. Army Research Lab hosted a workshop of NATO experts in IT and cyber and came up with numerous techniques and examples. Three key cyber resilience mechanisms mentioned are cyber deception, cyber agility, and clone defense. Deception is similar to NIST's discussion while agility refers to a moving target being harder to attack than a stationary target. This involves rotating components like the operating system or network stack to reduce vulnerability. Clone defense is the last mechanism; it means "reverting to a point of a last known good state of the system. This can be accomplished from snapshots taken on a virtual machine or via a known good backup system." This entails keeping a known state of good operations with the frequent snapshots providing a

31. Kott et al., *Approaches to Enhancing Cyber Resilience*, 5.
32. Ibid., 11-17.
33. Alexander Kott and Igor Linkov, eds., *Cyber Resilience of Systems and Networks* (Cham, Switzerland: Springer International Publishing, 2018) 12-16.
34. NIST, *Systems Security Engineering*, 88-89.

better ability to return to this state of good operations.[35] All of these methods are just techniques at achieving the end goal of returning to a known state of operations.

ARTIFICIAL INTELLIGENCE AS A RESPONSE TO RESILIENCY CHALLENGES

Artificial intelligence has received much attention in the last several years and could be seen as a solution to resiliency's problems with speed, modeling, and lack of human capital. Beyond running mere algorithms, the use of artificial intelligence could ideally allow a network to both function and heal at the same time. It could also involve decisions made in microseconds that better narrow threat parameters, allowing for quicker patches and restoration of operations.[36] In 2016, DARPA sponsored its Cyber Grand Challenge Final Event where it tested teams' abilities to respond to attacks, favoring the fastest response times to the obstacles. The best teams had defense structures that were self-healing and could continue to operate seconds or minutes after an attack that would have brought down most networks for days or months.[37] This combined many elements of resiliency discussed above but went further in using machine learning programs that could dynamically respond to complex threat environments. One could imagine the allure of applying these technologies to nuclear-related systems like components of NC3 or missile defense.[38]

AI in these cases would address the need for speed and agility. AI's ability to amalgamate dense data and focus the direction of decisionmakers could address the challenges of sifting through meaningless data and the difficulty of creating accurate models beyond the ability of current automation techniques. AI could potentially run many models in a short amount of time, creating refinement that would take human beings much longer. AI lastly could be seen as a supplement to a lack of human capital in the field. With limited experts in cyber within the DoD and the nuclear enterprise, AI could be used as the grunt workers performing many complex calculations and decisions. Humans would not have to be completely taken out of the loop as they could still manage the AI and direct its focus; this balances the need for more workers without completely giving up human oversight.

The allure of AI does not come without its own sets of warnings, however. Does the United States want an artificial intelligence system making decisions without human oversight? Beyond algorithms where humans have full control over machine automation and calculation, AI incorporates decisions made potentially outside the watch of human beings. One of the needs for AI mentioned above is speed and agility, which links to the core of why human authority might be ceded to AI. In these future scenarios, AI could help find solutions faster than humans could accomplish on their own—the only problem is that AI has now shaped the scope of the problem and taken the authority out of decisionmakers' hands. Practically, no decisionmaker wants less authority, especially when taken by a computer. But going further, reliance on automated systems that use AI could exacerbate the problem of "automation bias."[39] In this case, data is believed by human interface without critical analysis. Just

35. Kott et al., *Approaches to Enhancing Cyber Resilience*, 27.
36. Dustin Fraze, "Cyber Grand Challenge," DARPA, https://www.darpa.mil/program/cyber-grand-challenge.
37. Ibid.
38. The U.S. Air Force and MIT recently teamed up to launch the AI Accelerator with an objective "to advance the underlying science behind AI and facilitate societal applications." Among these applications, cyber resiliency is mentioned as a potential area of development this duo sees as beneficial to both parties. Rob Matheson, "MIT and U.S. Air Force Sign Agreement to Launch AI Accelerator," MIT News, May 20, 2019, http://news.mit.edu/2019/mit-and-us-air-force-sign-agreement-new-ai-accelerator-0520.
39. Beyza Unal and Patricia Lewis, *Cyber Security of Nuclear Weapons Systems: Threats, Vulnerabilities, and Consequences*, (London:

because the automation using AI tells the user it is useful or correct does not necessitate it (i.e., it still makes assumptions based on its programming which could result in incorrect solutions but which could be believed under an authoritative façade of AI). To compound the problem, does the United States want AI making decisions that could affect the use of nuclear weapons? This is not just the restoration of an installation's Wi-Fi but potentially of crucial nodes within the nuclear enterprise. The stakes are raised to the highest magnitude when considering the improper use of a nuclear weapon and whether AI could contribute such a catastrophic situation. These questions are meant to underscore the nascent understanding of AI and its applications across networks both civilian and military. Furthermore, these types of questions must be confidently answered prior to ever using AI in such sensitive areas as NC3.

BENEFITS FROM RESILIENT NUCLEAR NETWORKS

There are several potential benefits from crafting cyber-resilient systems for the nuclear enterprise; increasing cyber resiliency can positively increase situational awareness. The more cyber resilient a network is, the greater speed in which decisionmakers can act. This is a critical aspect of making networks more resilient. There needs to be significant confidence that a communication system that was attacked is actually functioning normally and providing the full range of communications needed for operations. This can be tested in real time; however, the longer it takes to figure out something is not working the less situationally aware decisionmakers are. The inability to reliably monitor early warning systems or missile detection systems due to cyberattacks would also severely decrease the ability to perceive an adversary's actions. Resilient systems would allow decisionmakers the use of these detection systems shortly after or during an attack and give them a high level of confidence in the information they are being provided.

Developing cyber-resilient systems also lessens the likelihood of miscalculation. The ability for the United States to respond to a cyberattack quickly and continue to reliably use NC3 contributes to nuclear stability in that it assists in bringing a degraded facet of the nuclear enterprise back to more normal operations. The negative in this case highlights several issues for non-resilient networks and systems. Lack of cyber resilient communication or detection capabilities is a problem two-fold in nature. Clearly, reacting to a potential nuclear attack without reliable networks tracking the appropriate information would be a recipe for disaster and instability. The fog and friction after a cyberattack are inherently destabilizing for decisionmakers. Additionally, the consequences of such an attack could affect planning, which in turn could alter the deterrence calculation. If the threat is perceived as credible, the very thought of operating with extremely degraded communications or weapons systems could change a country's nuclear posture. Though this reaction is not guaranteed, it is one response to such a situation.[40] This might mean the country could desire more nuclear weapons, or more survivable weapons, if it deems its current force insufficient to respond to a post-cyberattack environment. Resilient nuclear networks could allay this worry and positively contribute to situational awareness and the prevention of miscalculation.

Chatham House, January 2018), 1-4, https://reader.chathamhouse.org/cybersecurity-nuclear-weapons-systems-threats-vulnerabilities-and-consequences#cyber-risks.

40. Michael C. Horowitz, Paul Scharre, and Alexander Velez-Green, *A Stable Nuclear Future? The Impact of Autonomous Systems and Artificial Intelligence* (December 2019), https://arxiv.org/abs/1912.05291; Technology for Global Stability, *Artificial Intelligence and the Military: Forever Altering Strategic Stability* (Technology for Global Stability), https://www.tech4gs.org/uploads/1/1/1/5/111521085/ai_and_the_military_forever_altering_strategic_stability__t4gs_research_paper.pdf

Nuclear Threat Initiative (NTI) released a 2018 report from the Cyber-Nuclear Weapons Study Group and came up with four scenarios where a cyberattack could affect the nuclear enterprise.[41] Their second scenario entails a disruption of communication between diplomats, military officials, international counterparts, and operators after a cyberattack on both the United States and Russia. This example is highlighted due to the possibility of a cyberattack creating confusion not just for the United States but also for another country. This risk could lead to massive nuclear instability, for instance, if a country did not know whether it was under either a cyberattack or a catastrophic missile attack. Furthermore, in NTI's scenario, the Russians hopelessly try to confirm with the Americans what exactly is occurring. If an authority figure has to waste even minutes trying to gain situational awareness because of a cyberattack on lines of communication, calamity could ensue. Cyber resilient networks, communication lines, infrastructure supporting NC3 operations, warning systems, and weapons systems all increase stability in the nuclear world. They do this because deterrence relies on projecting a credible threat to an adversary and robust cyber resiliency restores some of the diminished credibility from a potentially debilitating cyberattack on nuclear networks.

OUTSTANDING QUESTIONS

There are a few outstanding questions to mention as a bridge to further discussion. First, there is a difficulty in broadcasting that a country indeed has a resilient system. This is not like the testing of an ICBM where a country knows with much greater certainty there is a credible nuclear deterrent. So while a resilient system might help the United States respond to an attack, will it do much to deter an attack? One possible way forward is to couple certain resiliency features related to nuclear communications alongside arms control verification, though this could present further questions for implementation and verification.

Second, vast disparities in both offensive or defensive cyber have the potential to destabilize. A country that knows an adversary has a cyber capability with the potential to debilitate networks associated with its nuclear forces might think it has no options left, thereby destabilizing the nuclear balance. Conversely, if an adversary knows that the United States has a credible resilient response capability, potentially rooted in new technology like AI, and the adversary does not have that capability, it may deem this disparity destabilizing since its own cyberattacks would be easily countered. Furthermore, no one really knows all the cyber capabilities of an adversary because they are subject to change and development based on a confluence of factors like advances in technologies, tactics, and changes in private industry. Thus, thinking a system or network is resilient may become a trap even if it is using technology like AI. A network may be able to defend against 95 percent of attacks, yet an adversary may keep their best single-use attacks for the time of the country's worst desperation. In this case, the system's resilience is great against the 95 percent of attacks that occur regularly throughout a given year, but will it be able to defend against the threat that has been kept in waiting?

CONCLUSION

Cyber resilience in the nuclear enterprise is operationally critical for all nuclear forces. It is also key to maintaining a credible nuclear deterrent in the face of advanced technologies, rising uncertainties, and evolving threats like APTs. Network defense in the nuclear realm will help prevent a debilitating

41. Page O. Stoutland and Samantha Pitts-Kiefer, *Nuclear Weapons in the New Cyber Age: Report of the Cyber-Nuclear Weapons Study Group* (Washington, DC: Nuclear Threat Initiative, September 2018), https://media.nti.org/documents/Cyber_report_finals-mall.pdf.

attack on critical networks like U.S. NC3. There will always be a level of uncertainty in prevention of attacks, however. This uncertainty is mitigated by robust cyber resilience across the nuclear networks. The ability to reliably respond after a cyberattack inherently increases stability and strategic awareness, adding greatly to the United States' overall deterrence posture.

There are challenges to cyber resilience that require creative ways to overcome obstacles, though they are not insurmountable. While there are outstanding difficulties associated with inflated trust in resilience and AI, the latter could be seen as an answer to several of the challenges facing cyber resilience. The United States will face problems associated with the supply chain for NC3 as modernization continues. Resilience in NC3 systems can lay the groundwork for faster responses to achieve network functionality amidst challenges from modernization. The United States can focus on the modeling and sensing algorithms that would allow an organization to accurately assess its health. It can also continue to employ any of the concrete resiliency techniques mentioned previously. Much of the literature on cyber resilience, however, involves not so much a discussion of emerging techniques and technologies as a change in processes and planning. The changes in processes and mindsets shifting from reactive to proactive cybersecurity can result in faster, more precise, and more persistent systems. The goal of creating resilient nuclear systems aims for complete restoration of network access, though it settles for enough access and information to reliably make accurate and timely decisions. Furthermore, cyber protection will continue to require the imaginative and resourceful minds JFK spoke of decades ago as rapid changes continue to emerge at unprecedented rates.

New Futures for Nuclear Arms Control

Examining a Framework and Possibilities with Hypersonic Weapons

Madison Estes[1]

ABSTRACT

While not "strategic" in the same manner as nuclear weapons, advanced dual-capable technologies born out of long-term technological improvements and advancements, such as hypersonic weapons, hold the potential to render strategic effect by eroding the survivability of strategic forces. Compounding existing disagreements, these trends have consequently undermined the robustness of nuclear deterrence and increased the complexity of maintaining U.S.-Russia strategic stability. The potential expiration of the New START Treaty serves as an opportunity to begin considering what cooperative measures may come next in a new era of advanced threats. While there are several narratives surrounding the threats hypersonic weapons pose to U.S.-Russia strategic stability, existing cooperative mechanisms offer a logical, accessible, and low difficulty starting point that has the potential to address most of these concerns simultaneously. Additionally, there are other steps that exist outside of these frameworks—and break with the START treaty family reductions paradigm—that may promote stability, but their feasibility will require additional investigation.

INTRODUCTION

At the time of this article's writing, the United States and the Russian Federation have withdrawn from the Intermediate-Range Nuclear Forces Treaty (INF) and are facing an unclear path ahead on the last standing pillar of bilateral cooperative strategic nuclear arms control, the Treaty between the United States of America and the Russian Federation on Measures for the

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Further Reduction and Limitation of Strategic Offensive Arms (New START). Though both parties have until 2021 to extend New START an additional five years, any such extension would only provide a temporary stopgap.

Setting aside the potential challenges to reach an agreement to the New START extension, both parties are facing a crossroads in the realm of cooperative nuclear arms control. Any follow-on cooperative framework to the New START agreement has the possibility of moving in several directions, including a complete break from seeking reductions or limitations in strategic nuclear systems or a pivot to different systems of concern.[2]

The United States and Russia have whittled down their nuclear forces to 656 and 524 deployed strategic delivery vehicles respectively as of March 2019.[3] Until both sides are ready to constrain themselves further in this category of systems, which is unlikely given the current geopolitical environment of great power competition, we may face a shrinkage in available avenues for strategic cooperation on nuclear issues. In a relationship that has been fraught with tension, a failure to identify areas where interests might converge may only lead to further instability, particularly when accounting for the potential loss of the transparency mechanisms that have been a beneficial byproduct of these treaties. The imminent expiration of New START should be approached as an opportunity to begin considering what comes next in maintaining strategic stability in a resurgent era of great power competition that wields advanced threats, including a potential break with the START treaty family reductions paradigm.

To find some new means of strategic cooperation, this article will review arguments surrounding the potential dangers of hypersonic weapons and offer some preliminary ideas for mitigating these risks. It begins with defining strategic stability and giving a brief overview of the Russian scope of the concept. Next there will be a brief explanation of the motivation to focus on hypersonic weapons for this analysis, then an identification of the narratives around hypersonic weapons and strategic stability. Each narrative is followed by excursions into potential cooperative mitigation measures. The article will close with a review of potential challenges and a conclusion.

With the goal of maintaining strategic stability serving as a guidepost, this analysis will offer a structured, replicable approach for evaluating and prioritizing other nonnuclear strategic systems that have the potential to impact the U.S. and Russian deterrents.

FRAMING THE CHALLENGE

Before considering potential positive options for what breaking from the START treaty approaches may look like, it is necessary to lay a conceptual foundation for any new proposals. Below is the conceptual framework that will be utilized to guide this analysis.

The concept of strategic stability has its origins in the Cold War, when the United States and Soviet Union were engaged in an ideological competition tinged with the threat and danger of nuclear weapons. The probability of an escalation to a nuclear exchange between the two superpowers was thought to be avoidable so long as the balance of mutual deterrence remained "stable."[4] The idea

2. In this context, the term "strategic" is being used in reference to long-range, intercontinental systems that can travel a distance of 5,500 kilometers or more.
3. "New START Treaty Aggregate Numbers of Strategic Offensive Arms," U.S. Department of State, March 1, 2019, https://www.state.gov/new-start-treaty-aggregate-numbers-of-strategic-offensive-arms/.
4. Brad Roberts, *The Case for U.S. Nuclear Weapons in the 21st Century* (Stanford, California: Stanford University Press, 2016), 121.

simply boils down to reaching a deterrence relationship where neither party perceives there is an advantage to be gained by attacking first in the event of a crisis or conflict.[5] This concept largely hinges on the force attribute of survivability, or the ability of one's own nuclear forces and associated command and control mechanisms, as well as an adversary's, to outlast an incoming nuclear attack and maintain the capacity to retaliate and impose costs.

In this context, the conversation around strategic stability has focused mostly on nuclear attacks against an adversary's nuclear forces, because for much of the nuclear age, available technology limited the ability for nuclear forces to destroy other nuclear forces. This has primarily been due to efforts to increase survivability. Such efforts can be implemented by taking steps like creating structural redundancy within a force posture, outfitting forces with mobility and stealth features so they become more difficult to find and track, and building in resiliencies such as hardened underground silos to make it more difficult to destroy and disarm fixed nuclear forces in a strike.[6]

Over the past few decades, technological trends in weapons accuracy, remote sensing, and data processing and communications have increased the vulnerability of nuclear forces.[7] These technological advances have not been limited to just nuclear weaponry, but have also improved and introduced new conventional offensive and defensive capabilities such as missile defense, precision-guided weapons, anti-satellite technology, hypersonic weaponry, cyber operations, and so on. Though these newly developed conventional systems are not "strategic" in the same manner as nuclear weapons, they have the potential to render strategic effect by challenging the survivability of strategic forces in a manner that was once thought only possible with nuclear weapons. In turn, this is challenging the robustness of nuclear deterrence and raising the complexity in maintaining strategic stability.

Though these challenges are "new" in the sense that they have only recently manifested with new technologies, they are actually in some ways only adding a layer to what was already a complicated problem set. The Russian Federation has consistently maintained a wider scope on what leads to strategic stability, arguing that it encompasses more than just nuclear threats and that it is also comprised of the larger military balance. Therefore, capabilities with the potential to undermine a relationship of mutual vulnerability are a threat to stability. Examples of this thinking can be traced back as early as the beginning of the U.S.-Russia arms control era with the first Strategic Arms Limitation Talks, to when subsequent disagreement on the development of ballistic missile defense (BMD) systems nearly sunk the Reykjavik talks in 1986, then later START II, and then a potential New START follow on.[8]

A more recent example of Russia linking strategic stability to a range of other issues outside of but related to strategic nuclear weapons is exhibited in remarks made by Foreign Minister Sergey Lavrov at the United Nations Conference on Disarmament in 2011: "We insist that there is a clear need to take into account the factors that negatively affect strategic stability, such as plans to place weapons

5. Thomas C. Schelling and Morton H. Halperin, *Strategy and Arms Control - 1961 Edition* (Mansfield Centre, CT: Martino Publishing, 2014), 50-51, 58-59.
6. U.S. Department of Defense, *2018 Nuclear Posture Review* (Washington, DC: U.S. Department of Defense, 2018): 43, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.
7. It is important to note that this increase in vulnerability has not occurred evenly, and this vulnerability has impacted some states and types of nuclear forces more than others. Keir A. Lieber, "The New Era of Counterforce" (presentation presented at the CSIS PONI Nuclear Scholars May 2019 Meeting, Washington, DC, May 24, 2019).
8. Alicia Godsberg, "Anti-Ballistic Missile Treaty Chronology," The Nuclear Information Project, https://fas.org/nuke/control/abmt/chron.htm and Brad Roberts, *The Case for U.S. Nuclear Weapons*, 124.

in outer space, to develop non-nuclear arms strategic offensive weapons, as well as unilateral deployment of a global BMD system."[9]

Despite this divergence in views, an appreciation of the strategic benefits of nuclear arms control in providing predictability and transparency, as well as being a mechanism for addressing concerns about each other's nuclear forces and postures, largely remains in the U.S. and Russian relationship.[10] Consequently, "U.S. and Russian experts disagree about the essential elements of a potential future bargain on reciprocal strategic restraint…' but, 'share a conviction that arms control agreements can have stabilizing benefits."[11]

MANAGING MULTI-DOMAIN NUCLEAR RISK

Now that we have framed the problem, we can postulate potential means of achieving our desired end state of strategic stability, or reducing incentives to conduct a nuclear first strike, while taking into account these nonnuclear strategic technologies. As briefly emphasized in the previous section, there are a myriad of emerging technologies—cyber, space, hypersonics, precision-guided systems, etc.—available to choose from when considering where to start.

To illustrate this point, a book project on strategic latency conducted by the Center for Global Security Research (CGSR) at Lawrence Livermore National Laboratory included a chapter on the global order and the technology revolution and provided a list of thirteen advanced technologies believed to be of current and future military significance. While the chapter does not address all the emerging technologies raised in this paper (for example, ballistic missile defense), it is useful as an analytically vetted list of technologies that includes several offensive technologies that have applicability to nuclear relationships.[12]

For the purposes of scoping, we will choose to focus on one technology for this paper: hypersonic weapons. Hypersonic weapons are defined as any weapon that is capable of traveling at Mach 5 (about 3,800 mph) or above, and some argue it must also be maneuverable along its trajectory.[13] The United States has chosen to focus its hypersonic weapon research and development for nonnuclear warhead delivery, while Russia has primarily focused on the technology's use for delivering its nuclear warheads, illustrative of the dual-capability of the technology. Indeed, it is this feature as well as its high penetrability through active defenses that would make it an appealing system for the Russian Federation, as it ensures the flexibility requirements for implementing strategic deterrence by keeping the door open to both conventional and nuclear strike options while also challenging

9. Sergey Lavrov, "Statement by H.E. Mr. Sergey Lavrov," (presented at the Plenary Meeting of the Conference on Disarmament, Geneva, Switzerland, March 1, 2011), https://www.unog.ch/80256EDD006B8954/(httpAssets)/F2C753C466AD602DC-1257846005C3761/$file/1211RussianFederation.pdf.
10. Vincent A. Manzo, *Nuclear Arms Control Without A Treaty? Risks and Options after New START - Deterrence and Arms Control Paper No. 1* (Washington, DC: Center for Naval Analyses, 2019): 22, https://www.cna.org/CNA_files/PDF/IRM-2019-U-019494.pdf.
11. Brad Roberts, *The Case for U.S. Nuclear Weapons*, 122.
12. For the full list refer to Paul Bracken, "New Technologies and International Order," in Strategic Latency: *Red, White, and Blue: Managing the National and International Security Consequences of Disruptive Technologies*, eds. Zachary Z. Davis and Michael Nacht (Livermore, CA: Lawrence Livermore National Laboratory, 2018): 104–14, https://cgsr.llnl.gov/content/assets/docs/STATEGIC_LATENCY_Book-WEB.pdf.
13. David Axe, "How the U.S. Is Quietly Winning the Hypersonic Arms Race," *Daily Beast*, January 16, 2019, https://www.thedailybeast.com/how-the-us-is-quietly-winning-the-hypersonic-arms-race?ref=scroll. Technically intercontinental and submarine-launched ballistic systems are capable of traveling at hypersonic speeds, but they follow a ballistic trajectory and do not have the same maneuverability features as the hypersonic systems discussed here. See U.S. Department of Defense, *2018 Nuclear Posture Review*.

the United States' globally deployed missile defense systems.[14] Hypersonics typically take the form of either an advanced cruise missile, usually known as a hypersonic cruise missile, or an advanced maneuverable reentry vehicle that can be mounted on a ballistic missile, also referred to as a hypersonic glide vehicle (HGV).[15]

Aside from hypersonic missile systems being listed as an advanced technology of significance in the previously mentioned CGSR study, another driver behind its selection for this analysis is that both the United States and Russia are prioritizing investments in these systems as a means of countering one another's hypersonic weapon and missile defense developments. Following the release of the Missile Defense Review in February 2019, in which the U.S. Defense Department articulated its intent to aggressively prioritize kinetic and non-kinetic countermeasures against hypersonic weapons as well as ballistic and cruise missiles, U.S. defense contractor Lockheed Martin received an order of more than $800 million from the U.S. Navy to "design, develop, build, and integrate technologies to support the flight test demonstration of a new hypersonic boost-glide weapons system."[16] This award is for the Intermediate Range Conventional Strike Weapon System program, which is an "early step in developing a hypersonic glide weapon body for all the services by 2025."[17] Additionally, Lockheed Martin received two contracts for two air-launched hypersonic systems, nicknamed Arrow and Hacksaw, from the U.S. Air Force in 2018.[18]

This shift in U.S. policy to focusing on a more comprehensive range of missile threats follows the Russian announcement in March 2018 of its pursuit of two nuclear-armed hypersonic weapons, which it has dubbed Avangard and Kinzhal. In his speech to the Russian Federal Assembly, President Putin states that the Avangard system is a response to the "deployment of the U.S. global missile defence system."[19] Though analysts projected it would not enter service into Russian strategic forces until the early 2020s, it has, in fact, defied expectations with a successful test in December 2018 and is planned to enter service by the end of 2019.[20]

HYPERSONICS AND STRATEGIC STABILITY

There are several arguments from both Russian and U.S. practitioners and scholars for why and how hypersonic missiles have the potential to degrade strategic stability. These can generally be binned into four broader categories of arguments: the first is the potential for exacerbating instabilities in the broader strategic balance, the second concerns escalation and crisis management, the third is ambiguity around the associated warhead, and last is ambiguity surrounding the missile's destination.

14. Heather Williams, "Hypersonics Disrupt Global Strategic Stability," *Jane's Intelligence Review*, February 6, 2017, 4.
15. James M. Acton, "Hypersonic Weapons Explainer," Carnegie Endowment for International Peace, April 2, 2018, https://carnegieendowment.org/2018/04/02/hypersonic-weapons-explainer-pub-75957.
16. U.S. Department of Defense, *2019 Missile Defense Review* (Washington, DC: U.S. Department of Defense, 2019): 58-59, 80, https://media.defense.gov/2019/Jan/17/2002080666/-1/-1/1/2019-MISSILE-DEFENSE-REVIEW.PDF.
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19. Vladimir Putin, "Presidential Address to the Federal Assembly" (address, Manezh Central Exhibition Hall, Moscow, Russia, March 1, 2018), http://en.kremlin.ru/events/president/news/56957.
20. Pavel Podvig, "Avangard System Is Tested, Said to Be Fully Ready for Deployment," Russian Strategic Nuclear Forces (blog), December 26, 2018, http://russianforces.org/blog/2018/12/avangard_system_is_tested_said.shtml, and for 2020 deployment predictions, see: Malcolm Claus, "Russia Unveils New Strategic Delivery Systems," *Jane's Intelligence Review*, April 11, 2018, 17.

ARGUMENT 1: HYPERSONICS HAVE THE POTENTIAL TO FURTHER EXACERBATE THE INSTABILITIES ALREADY PRESENT IN THE STRATEGIC BALANCE

Returning to the orthodoxy of a stable deterrence relationship, in which both parties are mutually vulnerable to the others' survivable nuclear assets and there is no advantage to be gained in striking first in a crisis or conflict, it is purported that hypersonics have the potential to challenge this. The primary way they do so is by offering a credible means of targeting an adversary's deterrent with a standoff strike option because of their speed and maneuverability.[21] They have the purported capacity to reach highly mobile targets located deep within an opponent's territory, which had previously been out of reach for most conventionally-armed missiles and—unless one sought to potentially start a nuclear war in the process—for most high speed, high powered nuclear-armed missiles.

U.S. IMPLICATIONS

There are some who would argue that nuclear-armed hypersonics such as the Avangard and Kinzhal do not necessarily alter the strategic balance any more than nuclear-armed ICBMs currently do in the Russian arsenal in terms of overcoming active defenses and penetrating deep targets, particularly as long as they remain deployed at niche capability levels.[22] There is also debate if U.S. missile defenses are as capable of stopping standard Russian nuclear systems from holding U.S. and allied territory at risk as the Russians seem to believe they are. Regardless, current U.S. policy states that its ballistic missile defense architecture is not intended to thwart Russian missiles. However, if the United States decides to shift away from this policy and to tailor its ballistic missile defenses to better defend against Russian capabilities, James Acton of the Carnegie Endowment for International Peace, an expert on hypersonic conventional weapons, has expressed confidence in U.S. regionally-based missile defense systems being capable of defending a small area from hypersonics if appropriately upgraded. However, he also states that the risk to the U.S. homeland, or another large territory, could not be as effectively defended without a high and unsustainable financial cost.[23]

RUSSIAN IMPLICATIONS

For Russia, which relies heavily on its mobile intercontinental ballistic missile (ICBM) force in its strategic deterrent, the ability for conventionally armed missiles to potentially degrade such survivable targets is concerning. Couple this with the installment of defensive systems like BMD and the concern multiplies. As highlighted in previous examples, Russia has repeatedly emphasized its disapproval of regionally based BMD systems. This disapproval primarily stems from the potential for such defensive measures to provide an additional layer of active protection that may undermine this principle of mutual vulnerability by negating most or, according to Russian rhetoric, potentially all of their nuclear potential and ability to effectively respond to a strike.[24]

POTENTIAL COOPERATIVE MITIGATION MEASURES

What arms control tools might effectively assuage Russian concerns that, while used in conjunction with active defenses, U.S. hypersonics (including large-scale conventionally armed employment) have the potential to guarantee one party absolute security? The same question can also be asked of mitigating the uncertain implications of Russian hypersonics (both conventional and nuclear-armed)

21. Williams, "Hypersonics Disrupt Global Strategic Stability," 3.
22. Axe, "How the U.S. Is Quietly Winning."
23. Acton, "Hypersonic Weapons Explainer."
24. In President Putin's speech, he stated that the United States was "permitting constant, uncontrolled growth of the number of anti-ballistic missiles, improving their quality, and creating new missile launching areas. If we do not do something, eventually this will result in the complete devaluation of Russia's nuclear potential. Meaning that all of our missiles could simply be intercepted." See Putin, "Presidential Address."

being able to overcome actives defenses to better hold targets inside the continental United States (CONUS) or allied territory at risk.[25]

An available starting point is to leverage the existing but moribund Strategic Stability Dialogue forum as a means of increasing transparency on the strategic intent for hypersonic systems and building some predictability. This transparency will be important for both the United States and Russia in making predictions about their own force posture and survivability requirements. A key to making this avenue of diplomacy work will be ensuring that neither side falls into the trap of believing that simply gathering in a room together will yield answers. Each must make a sincere effort to prepare for a substantive conversation by setting an agenda beforehand and coming prepared with both the relevant information and the right subject matter experts in attendance. This does not mean that the discussion cannot be approached from the conceptual level, but it does mean that both sides must be prepared to go deeper than their talking points.[26]

Another logical step that leverages existing mechanisms is to invoke the provisions of the New START treaty to begin procedures to incorporate some of these new nuclear-armed hypersonic weapons into the existing transparency regime. Indeed, in May 2019, U.S. undersecretary Andrea Thompson indicated the United States intends to do just that as these systems come online and New START remains in force. Her testimony before the Senate Foreign Relations Committee indicated that the United States would count the Avangard as an existing type, which would then subject it to New START counting rules and verification measures, including exhibitions of the new ICBM variant. Thompson also stated that Kinzhal (and other announced systems in Putin's address) should qualify as a "new kind of strategic offensive arm" as allowed by Article V of New START.[27] Ultimately the incorporation of the air-launched Kinzhal will come down to whether or not it is deployed on an aircraft that meets the definition of a heavy bomber and will also require a longer negotiation with Russia through the Bilateral Consultative Commission, which may run into some challenges.[28] To build confidence and encourage cooperation from Russia, the United States could offer some unilateral transparency into its conventionally-armed hypersonic weapons by providing some stockpile declarations and distribution of warheads. Or it could offer reductions or limits on something in return, such as the proposed nuclear sea-launched cruise missile (SLCM-N) announced with the 2018 Nuclear Posture Review, depending on its deployment status.[29] Because the INF Treaty

25. Podvig, "Avangard System Is Tested." At the time of this article's writing, there is no indication that the Russian Federation plans to deploy Avangard hypersonic missiles in anything more than a niche capacity and will still primarily rely on its traditional nuclear-capable delivery systems for its strategic forces. It would be prudent for the U.S. Departments of State and Defense to undertake further study to consider implications for a change in Russian posture that may choose to deploy a greater percentage of these missiles or the Kinzhal. A new composition of these forces with a greater emphasis on hypersonics and other technologies that evade active defenses could have large ramifications for a U.S. secure second-strike capability.
26. See Manzo, *Nuclear Arms Control Without A Treaty?*, 77-79 for a proposed working group model that could be utilized for this option.
27. Andrea Thompson, "The Future of Arms Control Post-Intermediate-Range Nuclear Forces Treaty," (testimony before the Senate Committee on Foreign Relations, Washington, DC, May 15, 2019), https://www.foreign.senate.gov/imo/media/doc/051519_Thompson_Testimony.pdf .
28. Indeed, the Russian Federation has already expressed some pushback regarding whether or not these new systems would qualify under the New START definitions of an ICBM, SLBM, and heavy bomber. See "Briefing by Foreign Ministry Spokesperson Maria Zakharova," The Ministry of Foreign Affairs of the Russian Federation, February 28, 2019, http://www.mid.ru/en_GB/foreign_policy/news/-/asset_publisher/cKNonkJE02Bw/content/id/3549162#29. Also refer to: Pranay Vaddi, "Bringing Russia's New Nuclear Weapons Into New START," Lawfare, August 13, 2019, https://www.lawfareblog.com/bringing-russias-new-nuclear-weapons-new-start.
29. The 2018 NPR stated that the pursuit of an SLCM-N was a direct response to Russian actions and meant to be a means of providing a "non-strategic regional presence, an assured response capability, and an INF-Treaty compliant response to Russia's continuing Treaty violation." See U.S. Department of Defense, *2018 Nuclear Posture Review*, 55.

is on its way out the door, it is possible the SLCM-N's intended use as leverage could be directed toward other capabilities like hypersonics.

A more ambitious proposal would be to consider a new framework that utilizes asymmetric (i.e., unequal) or adaptive limits, similar to what Dr. Aaron Miles proposed with Russian nonstrategic nuclear weapons and U.S. BMD.[30] This could help overcome the potential disparities in numbers as well as the divide between the conventional and nuclear space by allowing both sides to keep their selected capabilities with the condition that the other can choose to deploy more in response. As a simplistic example, such a framework might be that for every nuclear-armed hypersonic Russia chooses to deploy, the United States can deploy ten conventionally armed hypersonics or potentially ten missile defense interceptors as a countermeasure.

ARGUMENT 2: USABILITY AND ESCALATION LADDERS

Another argument surrounding hypersonic weapons is the potential negative impact their employment could have on escalation and crisis management. This argument has several narratives within it.

U.S. AND RUSSIAN IMPLICATIONS

One narrative is the impact that hypersonics, whether conventionally or nuclear-armed, could have on command, control, and communications (C3). Because of the weapons' unique flight path and trajectory, they have the ability to challenge current missile defense systems' early warning sensors and tracking.[31] Combining their probability of overcoming defensive architectures and their early warning components with their high-speeds may also "compress and disrupt an opponent's decision-making cycle" by diminishing the amount of time available to observe, orient, decide, and act.[32] Such compressed timelines might motivate parties to shift their execution of a launch-on-warning posture to earlier in a scenario, such as when the signal is first detected by satellite, bringing the risk of miscalculation and unintended escalation.[33]

A related concern surrounds these weapons' heavy reliance on space-based systems to guide their trajectories to their targets. Because it is difficult to target the delivery vehicle itself with missile defense, there would be strategic rationale in instead targeting their space-based guidance systems in order to disrupt their flight path. Unless the space-based asset is solely assigned to the hypersonic capabilities, such a decision may disrupt the owner's signaling and communications to other military assets, like intelligence and reconnaissance assets or legs of its strategic forces, raising the risk of miscalculation and/or escalation as well by potential consequences such as blinding an opponent or rendering part of their forces nonfunctional and encouraging an escalatory response.[34]

U.S. IMPLICATIONS

The second narrative within this argument is the fear that hypersonic missiles armed with conventional warheads might be viewed as more usable than their nuclear-armed counterparts or other nuclear systems, including employment against strategic assets and their infrastructure, because they are seen as less escalatory or a method of damage control. Moscow has been relatively open about its concerns that U.S. conventionally-armed hypersonics may offer an

30. Aaron Miles, "Adaptive Warhead Limits for Further Progress on Strategic Arms Control," RealClearDefense, February 6, 2017, https://www.realcleardefense.com/articles/2017/02/07/progress_on_strategic_arms_control_110760.html.
31. Claus, "Russia Unveils New Strategic Delivery Systems," 8
32. "Strategic Policy Issues," *Strategic Survey* 118, no. 1 (January 2018): 23–67, https://doi.org/10.1080/04597230.2018.1533078.
33. Alexey Arbatov, "New Global Strike Systems Create Serious Problems for Russia." Yabloko, October 24, 2013, https://carnegie.ru/2013/10/24/new-global-strike-systems-create-serious-problems-for-russia/gtpk.
34. Williams, "Hypersonics Disrupt Global Strategic Stability," 5-6.

appealing way to target their nuclear forces and C3 without actually crossing the nuclear threshold and subsequently placing the burden of escalation on Russia.[35] This problem, in turn, raised debate in Russia about what would be a proportional and credible response, and if threatening a nuclear response to a nonnuclear attack would be seen as a credible threat and sufficiently deter the United States.[36]

POTENTIAL COOPERATIVE MITIGATION MEASURES

If these narratives surrounding C3 or the setting of unrecognized or ignored escalation thresholds are determined to be of utmost concern, there are several cooperative pathways that could help lower these risks.

One proposal is to again leverage the existing New START treaty mechanisms to bring the new nuclear-armed Russian technologies in as new types and new kinds, which is an option for helping the United States gain a better understanding of the technical features and distinguishing characteristics of these systems.[37] Such information would be useful to make defensive upgrades and improve early warning sensors and systems tracking, improving confidence in detection and defensive capabilities and thereby reducing incentives to shift to earlier timelines in a launch-on-warning posture.

Another potential cooperative measure would be a mutual pledge codified in a presidential memorandum of understanding to not target or interfere with space-based satellites and technologies. This would be similar to the mutual agreement under New START of noninterference of national technical means. This mutual restraint option should help reduce the risks of unintended escalation and miscalculation by lowering the risks to military C3 assets and the temptation to preempt by conducting a swift first strike against these assets before the other can.

For the final narrative of usability and lowering of conflict thresholds, this would be another useful discussion for both sides to have within the Strategic Stability Dialogue forums. This forum provides an opportunity for both parties to clarify their intended use for these capabilities and under what circumstances they might consider an attack with these systems as a step that would warrant an escalatory response. The United States has spent the last decade assuring Russia that its intent for its conventionally armed hypersonics is not directed toward Russia; however, given Russia's opacity around the subject of its own nuclear-armed systems, it may prefer to shift its position. Frank dialogues on the strategic intent of their deployment would illuminate and improve best guesses of what both might see as credible deterrent postures in response.

ARGUMENT 3: HYPERSONICS' DUAL-CAPABILITY CAN POSE AMBIGUITY AROUND THE NATURE OF ITS PAYLOAD

A consistent argument on disrupting strategic stability is the issue of warhead ambiguity. This argument's roots trace back to the George W. Bush administration and the Conventional Trident Modification program, which would have placed conventionally armed submarine-launched Trident D-5 missiles alongside nuclear-armed missiles. This idea was feared to be destabilizing because it would

35. James M. Acton, "Russia and Strategic Conventional Weapons: Concerns and Responses." *The Nonproliferation Review* 22, no. 2 (April 3, 2015): 144–145, https://doi.org/10.1080/10736700.2015.1105434.
36. Arbatov, "New Global Strike Systems."
37. This could be primarily achieved through exhibitions as allowed under Article XI, Section IV of the treaty. "New START Treaty Aggregate Numbers of Strategic Offensive Arms," U.S. Department of State, March 1, 2019, 14-15, https://www.state.gov/new-start-treaty-aggregate-numbers-of-strategic-offensive-arms/.

be challenging to differentiate between missiles upon launch from what had traditionally been a solely nuclear mission platform, making it difficult for the intended recipient to tell whether they are about to absorb a conventional or nuclear strike and potentially resulting in a miscalculated response.[38]

In order to dispel these fears and continue pursuing its prompt global strike capability, the United States sought means of separating the two in a detectable way. The two primary ways this was done was through designating deployment and launch sites that were geographically distinct from the locations of its nuclear forces in CONUS and adding a hypersonic boost-glide vehicle that would alter its trajectory to not follow a traditional ballistic flight path, therefore making it distinct from a nuclear-armed ICBM.[39] Additionally, the United States has maintained its hypersonic programs intend to remain conventional.[40]

U.S. IMPLICATIONS

Unlike the United States' approach, Russia has not thus far sought to keep its long-range systems, including hypersonics, as distinguishable. The Avangard system's dual-capability offers Russia a flexibility that is in line with its strategic doctrine, which likely would make it appealing to not task it with a solely conventional or nuclear mission. Additionally, as of May 2019, it appears that the Avangard will be deployed within the Russian ICBM force at the Dombarovskiy ICBM base.[41] The current state of play also means a distinct trajectory and flight path is not as helpful in the present day, except for Russia being able to better distinguish U.S. systems. To put it plainly, the narrative around warhead ambiguity remains but has the potential to now become the United States' problem rather than Russia's.

POTENTIAL COOPERATIVE MITIGATION MEASURES

Thinking through this modernized problem set that accounts for recent Russian developments, one step to increase predictability would be to seek reciprocity from Russia in formally declaring the locations of their deployed hypersonics.

Once more, this is an area where the New START Treaty could serve as a means of sharing such data through its required biannual data exchanges, as long as these systems are incorporated as a new type or kind. Though it would only include Russia's nuclear-armed variants and not any conventional systems it may have, over time the information on their locations as well as any rolling notifications of their status would serve to bolster other data that the United States has and collects on Russian forces and provide better chances of locating where the nuclear-armed variants may originate from.

If New START is found to no longer be of strategic value and is not extended or renewed, it is theoretically possible that an entirely new transparency regime borrowing some of the New START schemes, such as data exchanges, pre-launch notifications, and delivery vehicle and launcher notifications, could be made for conventional and nuclear-armed hypersonics. This would be an ambitious approach that would likely have difficult buy-in for both the United States and Russia until tensions diminish. However, given the uncertainty of New START's future, further study of an independent regime should be conducted in order to prepare for such an alternative future.

38. M. Elaine Bunn and Vincent A. Manzo, "Conventional Prompt Global Strike: Strategic Asset or Unusable Liability," *Strategic Forum*, no. 263 (February 2011): 14.
39. Ibid., 18.
40. Whether this distinction would even make a difference has been up for debate. Russian scholar Dr. Alexey Arbatov asserted that Russian radars would not be able to confirm the launch of a boost-glide in a timely fashion and Russian specialists would have to act under the assumption that they are armed with a nuclear warhead. See Arbatov, "New Global Strike Systems."
41. Podvig, "Avangard System Is Tested."

ARGUMENT 4: HYPERSONICS' MANEUVERABILITY FEATURE AND UNIQUE FLIGHT PATHS CAN CAUSE DESTINATION AMBIGUITY

The final argument, its challenges to a stable deterrence relationship, and a possible solution that this paper will briefly explore is the potential for miscalculation due to the maneuverable nature of hypersonic systems, which has implications for both the United State and Russia. This feature has been identified as possibly destabilizing because of potential difficulty in identifying the vehicle's intended target. This uncertainty "complicates national defense mechanisms and response options, both nationally and internationally," because it is plausible even the intended recipient's neighbors may not be able to discern if it's headed for them or their neighbor depending on its direction.[42] Combine this with its high speed of travel and we have another example of the potential disruption and compression in the respondent's decision-making cycle. This may only become more exacerbated as Russia's nuclear-armed delivery vehicles come into service.

POTENTIAL COOPERATIVE MITIGATION MEASURES

A cooperative measure that could encompass both conventional and nuclear-armed hypersonics is the reestablishment of the U.S.-Russian Joint Data Exchange Center (JDEC), which was intended to share early warning information and be a repository for notifications of ballistic missile and space vehicle launches.[43] Starting up a new JDEC that included hypersonics and notification of the launch trajectory would be a prudent first step for promoting predictability and has the added benefit of potentially providing some insight on its potential payload by sharing its intended destination. Additionally, another added benefit in reestablishing a JDEC is that it could be executed outside of the New START framework if there is disagreement on formally incorporating them into the treaty or if the treaty is allowed to expire. The JDEC also has the potential to be multilateralized to assist neighboring countries that may also be threatened with the destination ambiguity issue and potentially incorporate China, which the United States has expressed interest in doing with future nuclear arms control arrangements, if conditions allow.

POTENTIAL CHALLENGES

The United States and Russia have a rich history of transparency and confidence-building measures that has built expertise and provided what is essentially a database—both in the literal and figurative sense—from which to draw upon to make judgments about the other side's strategic posture, intent, and what actions may or may not be appropriate in a crisis situation.

In pursuing new measures that encompass related weapons systems that have historically been excluded from this framework either because they did not yet exist or fell outside the bounds of the treaty, we will essentially be starting from scratch. Though some best practices and know-how may linger, developing arms control measures for hypersonic weapons will have their own set of unique challenges due to a myriad of factors such as size, production lines, dual-capability, sensitivity, legal protections, and so on—not to mention the reconciliation of potentially disparate systems and quantities under a limitations/reductions framework and the development of a verification and monitoring regime that is acceptable to both sides. The viability of the previous proposals and their unique challenges will require further study that is beyond the scope of this article.

42. Williams, "Hypersonics Disrupt Global Strategic Stability," 5.
43. Bunn and Manzo, "Conventional Prompt Global Strike," 20.

Additionally, it is important to acknowledge that a necessary precondition to pursuing these cooperative measures is these parties will have to determine that it serves their interests to do so. At this current point in time, there is no indication that this precondition will be met in the five- to ten-year horizon. The first reason this is the case is that for the foreseeable future, hypersonics offer Russia one of the better chances of countering regional missile defense architectures and U.S. advantages in conventional warfare.[44] The second reason is the impacts of these technologies have yet to be fully realized. In the words of one researcher, "With emerging technologies, right now it's unclear who is going to sort of 'win out' a number of contests—whether that's hypersonic, AI, cyber—any individual country is going to hope that it's going to 'win out'. It's going to have fewer incentives to engage in any limitations until this shakes out and these countries figure out where they land. Once we get there, countries will have more incentives to engage in more traditional arms control."[45]

CONCLUSION

The challenges for some of the proposals will no doubt be steep if pursued, but it does not mean that the United States and Russia cannot begin doing their homework on what cooperative options will serve their interests. Even though the contest may not yet be won, there is nothing that precludes prepping for what may happen next after a victor emerges. If the desire to promote predictability and stability in the U.S. and Russian nuclear relationship persists, it will become all the more important to sincerely engage in the full range of issues concerning strategic stability.

The ideas proposed in this study are merely starting points for engagement and a means of laying the groundwork for further study and creative discussion on potential options. As demonstrated by the analysis, there are existing diplomatic mechanisms like the New START Treaty and the Strategic Stability Dialogue that may offer a logical, accessible, and low difficulty starting point for addressing many of the reviewed arguments surrounding hypersonics and bringing each side closer to achieving strategic stability. However, they are by no means the only methods available. Regardless of which of the reviewed arguments is selected as being the most critical to solve, the United States should take the opportunity it has now to proactively shape the strategic environment while it is still feasible to do so.

44. Williams, "Hypersonics Disrupt Global Strategic Stability," 6 - 7.
45. Rebecca Davis Gibbons, presentation at the Future of Arms Control, Center for Strategic & International Studies, Washington, DC, April 3, 2019, https://www.csis.org/events/future-arms-control.

Will the Adoption of Artificial Intelligence-enabled Decision Support Tools by India Reduce Nuclear Stability with Pakistan?

Sam Guthrie[1]

ABSTRACT

This essay examines the potential impact of artificial intelligence (AI) on nuclear stability between India and Pakistan. The sources studied include statements by serving officials, papers discussing existing applications of the technology, and the academic literature on strategic stability and emerging technologies. I argue that the alluring prospects of AI in the nuclear and conventional domains are already driving Indian research and development. If Pakistan believed that India had AI-assisted intelligence capabilities that threatened to undermine the survivability of Pakistan's nuclear forces, this development could influence Pakistan's decisionmaking for the worse in any future crisis. Consequences include a reduction in Pakistan's confidence in its strategic deterrent, an increase in

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India's perceived ability to coerce and engage in brinksmanship, and the resumption of destabilizing behaviors on both sides.

INTRODUCTION

The purpose of this essay is to contribute to the limited base of knowledge on the impact emerging technologies will have upon the nuclear relationship between India and Pakistan. The development of emerging technologies will force the existing nuclear postures that underpin nuclear deterrence relationships between the two respective national command authorities to change and adapt. There is a high level of interest from India in the potential of AI (less so from Pakistan), as demonstrated by the number of statements of intent from Indian officials and examples of ongoing research. This essay draws on authoritative sources where possible and makes reasoned assumptions where not. Both are used to explore hypothetical projections of the future, in which India may more widely pursue and apply AI-enabled decision support tools. It is this point—the contribution AI might make to an existing Pakistani fear that India is pursuing counterforce capabilities—that makes the prospect of AI in the nuclear domain so destabilizing.

The subject of AI-enabled decision support in nuclear contexts is significant; it is through information provided and justifications given that nuclear decisions can be made. AI is already contributing to decision support in other domains; it stands to reason that nations will utilize AI-related technology for nuclear decision support in the future. It is therefore important to understand how these contributions will affect the relationships that maintain nuclear stability, both in crises and peacetime.

Consequently, the essay begins with an exploration of what aspects of AI are of relevance to nuclear operations generally, and South Asia specifically. The essay goes on to discuss how AI-enabled intelligence analysis, such as the tracking of nuclear assets through different intelligence sources, can undermine nuclear stability by reducing confidence in the survivability of nuclear forces. It concludes that there is a plausible argument for AI in the nuclear domain undermining strategic stability between India and Pakistan and offers recommendations for how these consequences might be managed or mitigated against.

WHAT IS ARTIFICIAL INTELLIGENCE AND WHY IS IT IMPORTANT?

AI refers to a field dedicated to studying the problem of developing intelligence in digital systems. AI is often misleadingly conflated with autonomy and other forms of computer assistance. So why is AI more concerning than improving automation in general? What is the step change that AI introduces to the equation? And why is this relevant to nuclear stability? A definition of AI proposed by the European Commission is:

> Artificial intelligence (AI) refers to systems designed by humans that, given a complex goal, act in the physical or digital world by perceiving their environment, interpreting the collected structured or unstructured data, reasoning on the knowledge derived from this data and deciding the best action(s) to take (according to predefined parameters) to achieve the given goal.[2]

2. AI High-Level Expert Group, *A Definition of AI: Main Capabilities and Disciplines* (Brussels: European Commission, 2019) https://ec.europa.eu/digital-single-market/en/news/definition-artificial-intelligence-main-capabilities-and-scientific-disciplines.

This definition is useful as it emphasizes the ability of the technology to reason and draw conclusions based on structured or unstructured data currently enabled through machine learning (ML). This ability to reason enables other technologies, such as computer vision,[3] to perform more efficiently on real-world data than existing manual methods. As a form of decision support, learning-enhanced computer vision can better inform analysts working with visual data and inform their reasoning and decisions in turn. The methods through which decision support can be delivered are detailed in Phillips-Wren's review of Decision Making Support Systems (DMSS), of which fuzzy logic networks pose the greatest opportunity for strategic decision support.[4] It is the provision of abilities (perceiving, interpreting, and reasoning) typically limited to biological intelligence that has been (and currently is) the step change that AI brings. The automation of "intelligent" processes such as reasoned decision support has been widespread for some time[5] and the utility of this automation, in faster decisionmaking and information processing, may be appealing to operators in the nuclear domain.

The aspiration to make use of automation and automated decisionmaking in nuclear operations is not new. The Survivable Adaptive Planning Experiment (SAPE) explored the possibility of using strategic computing to reduce nuclear war planning times from months to days.[6] This was to allow for adaptive planning in the midst of nuclear attack. Given the increasingly time-constrained environment in which decisionmakers (including those in India and Pakistan) operate in today, it is conceivable that states under threat will seek to maximize their available planning time. Unlike the SAPE algorithm which took human-generated inputs and prioritized them in the best possible way, a modern, sophisticated decision support algorithm could still take raw data, categorize and interpret it, and provide an analyst with a risk and success assessments. The two key benefits of introducing AI to this capability are self-improvement and finding alternative opportunities overlooked by human analysts.[7]

This was the ambition behind the Semi-Automatic Ground Environment (SAGE) supercomputer network of the 1950s: to supplement "the fallible, comparatively slow-reacting mind and hand of man."[8] While the planned computer network was deemed vulnerable to ICBM attack, the proliferation of high-capacity cloud computing may breathe new life into the strategic computing field.

A team from the University of Missouri's Center for Geospatial Intelligence has applied these techniques in practice, developing a machine-learning algorithm to identify and rank potential Chinese surface-to-air missile (SAM) sites "with a 98.2 [percent] average accuracy."[9] The algorithms were trained using "fewer than 100 positive training examples," which represents a significant improvement over older techniques. From a technical perspective, this is what ML-assisted Indian automated target recognition (ATR) could look like. This would be one application of perception AI. Of course, it would be extraordinarily difficult to generate the kind of training set that would be required to make an effective AI-enabled decision support tool for nuclear operations. Given the emphasis on

3. Computer vision regards the ability of digital systems to make use of visual inputs, such as images or videos.
4. Gloria Phillips-Wren, "AI Tools in Decision Making Support Systems: A Review," *International Journal on Artificial Intelligence Tools* 21, no. 2, (2012).
5. Ibid., table 1.
6. Alex Roland and Philip Shiman, Strategic Computing: *DARPA and the Quest for Machine Intelligence, 1983-1993* (U.S.: MIT Press, 2002) 304-306.
7. U.S. House of Representatives, *Department of Defense Appropriations for 1987: Hearings before a subcommittee of the Committee on Appropriations*, 99th Cong., 2nd sess. (1986), 264.
8. Jaganath Sankaran, "A Different Use for Artificial Intelligence in Nuclear Weapons Command and Control," War on the Rocks, April 25, 2019, https://warontherocks.com/2019/04/a-different-use-for-artificial-intelligence-in-nuclear-weapons-command-and-control.
9. Richard A. Marcum, Curt H. Davis, Grant J. Scott, Tyler W. Nivin, "Rapid broad area search and detection of Chinese surface-to-air missile sites using deep convolutional neural networks," *J. Appl. Remote Sens* 11, no. 4, (October/December 2017), 042614-3.

concealment and deception for ensuring the survival of nuclear forces, it is likely difficult to obtain quality training images of deployed systems. However, due to improving technologies in the 3D rendering and image generation space, synthetic visual training sets are already being marketed for machine learning.[10] Given how few examples were required by the Center for Geospatial Intelligence's machine vision experiment, this could be a plausible avenue for machine learning without an extensive data set.

Furthermore, AI need not deliver on the capabilities it promises in order to impact deterrence and decisionmaking. Much like "Star Wars," the Strategic Defense Initiative proposed by President Ronald Reagan in 1983, AI in a nuclear context has the potential to disrupt stability long before it is technologically ready. Perceptions may matter as much if not more than reality. This risk was highlighted by Soviet physicist Roald Sagdeev, who noted that "If Americans oversold [SDI], we Russians overbought it."[11]

WHY INDIA AND PAKISTAN?

India inhabits two strategic triangles, acting as a major player in Sino-U.S. and Sino-Pakistan relations. For the United States, India is an "anchor of stability" and "Major Defense Partner" in a region of strategic importance and as a notional counterbalance to Chinese regional ambitions.[12] Demonstrating the importance of this relationship, the recently launched U.S.-India 2+2 dialogue acts as a shared forum for security discussions in the Indo-Pacific and beyond.[13] India's security relationship with China is somewhat less friendly, though both sides seemingly have little to gain from direct confrontation. The drivers of the 1967 Sino-Indian War still remain, resulting in largely bloodless border skirmishes such as the Doklam confrontation in 2017. Despite this, the attitude from both sides seems to be conciliatory and military restraint between the two sides is common.[14] By contrast, the Sino-U.S. relationship is openly competitive and both sides are looking to secure their interests in the Pacific and beyond. This competitive relationship also spills over into the AI field. Frequent references to an AI arms race have been made by commentators in regard to U.S. and Chinese investment and development in the field. The other strategic triangle of India, China, and Pakistan also demands improved capabilities for all parties. Numerous Indo-Pakistan crises, from direct military confrontation in the Kargil conflict[15] to cross border terrorism in Mumbai,[16] have strained the relationship between India and Pakistan. As nuclear rivals in a deterrence relationship, both have an interest in ensuring conventional conflicts do not escalate out of hand.

The United States, Russia, and China already recognize the importance of AI in a number of future military and strategic roles. India feels a similar imperative to develop technologies for defense, illustrated by the role of the Defense Research and Development Organization (DRDO) Center for Artificial Intelligence and Robotics (CAIR)[17] labs and their aim of "establishing Artificial Intelligence

10. "Customised Photorealistic Datasets for Real-World Tasks," Datagen, http://www.datagen.tech/.
11. Dwayne A. Day and Robert G. Kennedy III, "Soviet Star Wars," *Smithsonian Air and Space Magazine* (January 2010) https://www.airspacemag.com/space/soviet-star-wars-8758185/?all.
12. "Joint Statement on the Inaugural U.S.-India 2+2 Ministerial Dialogue" U.S. Department of State, September 6, 2018, https://www.state.gov/joint-statement-on-the-inaugural-u-s-india-22-ministerial-dialogue/.
13. Ibid.
14. Manoj Joshi, "The Wuhan Summit and the India-China Border Dispute", *Observer Research Foundation*, no. 62 (June 2018): 1-20.
15. The Kargil border conflict took place in 1999 and involved direct military contact between the two sides.
16. The Mumbai attacks were conducted by a Pakistan-based terrorist group in 2008.
17. Defense Research and Development Organization, Center for Artificial Intelligence and Robotics.

(AI) technologies which can be applied for the rich problem areas within the military."[18] Geographical Information System (GIS) technology, decision support systems, and object detection and mapping are all given as focus areas for DRDO research in the preceding source. These technologies, while currently being applied to conventional military issues, also have significant utility to problems in the nuclear domain. Indian defense Public Sector Undertakings (PSUs) such as Bharat Electronics Limited (BEL) are already in the process of developing and fielding military equipment with AI capabilities. One prominent example is the AI-enabled patrol robot being developed by BEL in anticipation of demand from the Indian military.[19] Furthermore, ML support to decisionmaking is being discussed in the Indian national security think-tank community,[20] which may drive official interest in the near future. This is especially true given DRDO is purportedly already providing an ML-supported Decision Support System (DSS) to military logistics and coastal surveillance.[21] Given the above, a plausible future exists in which these AI capabilities are applied to the rich problem areas in the nuclear domain, which in turn will affect nuclear stability.

In contrast to India, Pakistan has almost no high-level guidance on applications of AI technology outside of the Presidential Initiative for Artificial Intelligence and Computing (PIAIC).[22] As such, they are likely to linger behind other regional actors due to other, more pressing national priorities. This creates the potential for a gulf to emerge between Indian and Pakistani capabilities in this field, posing risks in of itself. As Pakistan may not have a widespread awareness within official circles of the scale and implications of such a gulf in capability, it may become vulnerable to a sudden strategic surprise as the gulf is recognized. The scale of Pakistan's response may need to be equally drastic, if asymmetric, potentially driving further military procurements or developments in doctrine and practice.

COMMUNICATION, SECRECY, AND MISPERCEPTION

When senior figures issue official statements of interest in areas of technological development, they can be seen as setting the context around research and development efforts. India's stated interest in applying AI to military problems—expanded upon below—has been sufficiently vague to risk leading a skeptical audience, such as Pakistan's strategic affairs community, to worry about broader Indian ambitions in the future. This may be especially true as several of India's stated areas of interest in AI development may be of use as generic tools to both conventional military and nuclear problems. If AI capabilities such as these are developed in secret, an adversary cannot factor them into their plans and would risk jumping to worst-case conclusions with deleterious impact on strategic stability.[23] As such, it makes sense to advertise a new capability through technology demonstrators or research and development in public view. This regularly occurs with new strategic systems in South Asia; the Indian K-15 missile and Pakistan's low yield nuclear weapons development are examples. Statements by senior political or military figures often have the most visibility, but communication can also

18. "Major Products," DRDO CAIR, July 8, 2019, https://www.drdo.gov.in/drdo/labs1/CAIR/English/indexnew.jsp?pg=products.jsp.
19. Chethan Kumar, "India working on robots that may patrol borders," *Times of India*, May 2, 2019, https://timesofindia.indiatimes.com/india/toi-exclusive-india-working-on-robots-that-may-patrol-borders/articleshow/69138606.cms.
20. Debasis Dash, *Autonomy and Artificial Intelligence: The Future Ingredient of Area Denial Strategy in Land Warfare*, (New Delhi: Centre for Land Warfare Studies, 2018) https://www.claws.in/images/publication_pdf/1532765361_AutonomyandArtificialIntelligence_CLAWS(MP75FINAL).pdf.
21. "Major Products," DRDO CAIR.
22. Arif Alvi, "Pakistan's place in Artificial Intelligence and computing," *Pakistan Today*, January 19, 2019, https://www.pakistantoday.com.pk/2019/01/19/pakistans-place-in-artificial-intelligence-and-computing/.
23. An illustration of this principle is given in the 1964 satirical film *Dr. Strangelove*, in which the secret development of a Soviet doomsday machine is only revealed following the outbreak of nuclear conflict. The unknown capability of the Russian "Perimeter," or Dead Hand, system poses a similar risk.

be achieved through actions and signaling, like the convening of Pakistan's national command authority in February 2019. Conversely, an actor might want to keep a new capability secret to maximize the military advantage to be gained from it. In other cases, the actor might make the effect they wish to achieve known, such as enhanced border monitoring, but keep the means secret, as with reconnaissance satellites. While the official statements below don't explicitly refer to nuclear applications, there is likely to be consistency in thinking between delivering conventional military requirements and delivering the nuclear mission.

One of the primary documents of interest is a report by the Indian Ministry of Defense's AI Task Force. While the full report remains classified, the government's Press Information Bureau makes reference to its findings. The press statement highlights "military superiority" as an application of AI, including in the realms of "cyber, nuclear, and biological[24] warfare."[25] Consultation with "senior representatives from . . . all Defence [Public Sector Undertakings]," the Army, Navy and Air Force commands informed the findings of the AI Task Force. India's Army Chief, General Bipin Rawat, stated in 2019 that AI and "big data" cannot be left in the military glossary.[26] As a result, the Army "identified technologies that need to be incorporated [into India's military enterprise] . . . in a significant manner," of which AI is one.[27] This statement was followed by another, that "our adversary on the northern border (China) is spending huge amounts of money on Artificial Intelligence and cyber warfare. We cannot be left behind."[28] Reinforcing this school of thought in Indian defense, Minister of State for Defense Shubhash Bhamre highlighted that "supremacy [would be] defined by the technology differential of adversaries."[29]

Another discussion on AI and national security takes place in the Government of India's *Report of the Artificial Intelligence Task Force*. It is unclear as to whether the Ministry of Defense's AI Task Force is linked to the Ministry of Commerce and Industry's AI Task Force. Identical names, but seemingly different conclusions, would suggest that effort is being duplicated across different ministries. The conclusions were written so "follow-up action can be immediately planned," though progress is unclear. Regardless, national security was identified as one of 10 "domains of relevance to India" in this report.[30] Autonomous surveillance is highlighted for immediate development, and the U.S. Department of Defense's Project Maven is given by the Task Force as an example of perception AI's technological maturity. Comprehensive intelligence fusion, coastal and border surveillance, as well as cross border infiltration monitoring, are also areas of interest. All of these capabilities would allow for application in the conventional military or nuclear domains, even if it were not the initial intent.

On Pakistan's side, discussion of AI as a military capability has been more circumspect, as demonstrated at the 2019 launch of President Alvi's PIAIC. He stated that "our future economy and

24. One would presume that this refers to purely defensive biological capabilities, as both India and Pakistan are states party to the Biological and Toxin Weapons Convention. The mention of biological and nuclear, with the omission of chemical and radiological, is worthy of note.
25. "AI task force hands over Final Report to RM," Government of India Press Information Bureau, August 30, 2018, http://pib.nic.in/newsite/PrintRelease.aspx?relid=180322.
26. Press Trust of India, "Will be too late if work doesn't begin on incorporating AI into armed forces' system: General Rawat," *Economic Times*, January 11, 2019, https://economictimes.indiatimes.com/news/defence/will-be-too-late-if-work-doesnt-begin-on-incorporating-ai-into-armed-forces-system-general-rawat/articleshow/67488784.cms.
27. Ibid.
28. Press Trust of India, "Army Chief for tapping AI, Big Data for defence forces," Economic Times, January 21, 2019, https://economictimes.indiatimes.com/news/defence/army-chief-for-tapping-ai-big-data-for-defence-forces/articleshow/67620009.cms?from=mdr.
29. Press Trust of India, "Will be too late if work doesn't begin on incorporating AI."
30. Anurag Agrawal et al., *Report of the Artificial Intelligence Task Force* (The Ministry of Commerce and Industry, 2018), https://dipp.gov.in/whats-new/report-task-force-artificial-intelligence.

defence systems will strongly depend on our own skills to be a part of the great [AI] revolution."[31] From the perspective of the military, retired vice admiral Arifullah Hussaini stated in 2018 that "the future of war does not belong to conventional methods but artificial intelligence. Whosoever uses it well will win."[32]

These examples serve to demonstrate that there is a multilevel interest across government and the military on the Indian side as to the application of AI for national security purposes. Official comments about "superiority" and "supremacy" being the goal of AI development serve as a message, whether intentional or not, to the opposing side. The fascination with transformative effects stemming from the introduction of AI into national defense seems to be widespread, and this will likely not go unnoticed by Pakistan. It would be prudent of Pakistan's military and political authorities to be considering how the introduction of AI force multipliers in these contexts may affect strategic stability.

AI, DETERRENCE, AND STRATEGIC STABILITY

Leiber and Press, discussing nuclear deterrence in the computer age, highlighted the "eroding foundation of nuclear deterrence" as a consequence of improved weapon accuracy and remote sensing.[33] While weapon accuracy lies outside the scope of this paper, there is a credible argument that improved remote sensing is eroding the foundation of nuclear deterrence between India and Pakistan. Unlike the nuclear forces of Russia, the United States, or even India, Pakistan cannot rely on strategic depth or a diversity of capabilities to assure a second strike. With limited stocks of fissile material and a constrained ability to operate at sea, Pakistan primarily relies on its delivery system diversity, dispersal and concealment of systems, and doctrine of "last resort, but first use" to ensure the credibility of its nuclear forces.[34] Pakistan has a flexible response doctrine under which it retains the option to go nuclear in response to perceived existential threats, such as a major Indian offensive into Pakistan's territory.[35] Nuclear delivery capabilities range from the mobile short-range Hatf 9 "Nasr" to the mobile medium-range Shaheen 3, allowing Pakistan to select from a range of Indian targets below the ICBM range. Test flights are being conducted for the Haft 7 cruise missile to prove its ability to operate at sea. Pakistan also operates dual-capable aircraft (DCA) from which nuclear weapons can be delivered.

India, in contrast, has an assured retaliation doctrine under which a possibly massive nuclear response would result from Pakistani nuclear first use. This is underlined by India's No First Use (NFU) policy, which was first outlined in 2003 and reaffirmed by Prime Minister Modi in 2018.[36] At present, nuclear weapons assume a less prominent role in India's deterrence strategy because of its conventional superiority over Pakistan. This superiority is set to increase as India makes progress in important fields, such as developing domestic endo- and exo-atmospheric ballistic missile defense (BMD) and cruise missile defense. Further changes in India's strategic capabilities may be

31. Arif Alvi, "Pakistan's place in Artificial Intelligence and computing," https://www.pakistantoday.com.pk/2019/01/19/pakistans-place-in-artificial-intelligence-and-computing/.
32. Muneeb Mobin, "Bringing India to negotiating table is only sensible option for regional peace," *DAWN*, March 23, 2018, https://epaper.dawn.com/DetailImage.php?StoryImage=23_03_2018_118_006.
33. Kier A. Leiber and Daryl Press, *Nuclear Deterrence in the Computer Age: The Erosion of Stalemate*. (Cambridge, MA: Belfer Center for Science and International Affairs, 2017) https://www.belfercenter.org/publication/nuclear-deterrence-computer-age-erosion-stalemate.
34. Sannia Abdullah, "Pakistan's Full-Spectrum Deterrence: Trends and Trajectories," South Asian Voices, December 13, 2018, https://southasianvoices.org/pakistan-full-spectrum-deterrence-trends-trajectories/.
35. Ibid.
36. Manpreet Sethi, "Perceptions of India's Nuclear Capability Buildup: Ghost Hunting and a Reality Check", *Diplomat*, April 2, 2019, https://thediplomat.com/2019/04/perceptions-of-indias-nuclear-capability-buildup-ghost-hunting-and-a-reality-check/.

the proposed acquisition of the Russian S-400 system and U.S. capabilities stemming from India's mention in the U.S. 2019 Missile Defense Review.[37] Other capabilities and developments, such as those in the hypersonic missile, cyber, cruise missile, and stealth areas have the potential to upset the strategic balance even further.

To be resilient against counterforce targeting, nuclear weapons systems need to be survivable, concealed, and diverse. They first need to avoid being found, but if they are, they need to survive long enough to be able to execute a strike, if required. If their survival is jeopardized, there should be enough delivery systems to ensure that a credible retaliation can be delivered. This is especially important for India and Pakistan, as their nuclear arsenals are primarily land-based. In contrast, states including the United States, Russia, and France favor submarine-based nuclear weapons to guarantee concealment and survivability. India has explored this possibility for years with the INS Arihant ballistic missile submarine (SSBN). Pakistan is also interested in having nuclear weapons at sea, with the ambition of deploying the nuclear-capable Babur-3 submarine-launched cruise missile (SLCM) aboard diesel-electric submarines. As it stands, however, Pakistan relies primarily on a land-based nuclear arsenal. The difficult terrain and independent mobility of transporter erector launcher (TEL) vehicles provide a high degree of concealment, but with time, patience, and the application of ML assisted surveillance processes, it may be possible to detect a majority of dispersed TELs. For other nuclear weapons, such as air-dropped gravity bombs or cruise missiles, Pakistan relies on hardened nuclear stockpiles to arm DCA before or after dispersal. These stockpiles need to be survivable and diverse enough to minimize the risk of a successful counterforce strike.

If India were to integrate an ATR or AI-enabled processing tool into an intelligence cycle, such as the Intelligence Process used by the U.S. Department of Defense,[38] one might expect the following changes and improvements.[39] During the planning and direction stage, prioritization of intelligence gaps identified by intelligent reasoning by the system would allow for semi-autonomous collection, somewhat improving the responsiveness and timeliness of the intelligence process as well as continual self-evaluation. The ML-enabled collection would then be expected to offer evolutionary improvements over existing capabilities. It has the potential to improve asset tasking using a combination of predictive analytics and machine learning, and assets can be re-tasked as the system reasons on how effectively collection requirements are being met. The labor-intensive processing and exploitation stage would stand to benefit greatly from general automation. Data typically too complex for automation can be addressed with AI technologies including machine vision, natural language processing, and speech processing. Through the same means, analysis and production of intelligence can be bolstered by AI by allowing the system to provide its own reasoning on the data it processes. During dissemination and integration of intelligence, there is a role for AI in determining effective distribution means and ensuring information security as well as aiding weapon assignment to targets and planning. As such, AI technologies have the potential to bring evolutionary benefits to each stage of the intelligence process.

As a result, India's deterrence relationship with Pakistan could be affected in a number of ways. First, in a crisis, immediate deterrence may be compromised by the mitigating measures taken by Pakistan to heighten its forces' survivability. For example, improved intelligence would better

37. Office of the Secretary of Defense, 2*019 Missile Defense Review* (Washington DC: U.S. Department of Defense), https://www.defense.gov/Portals/1/Interactive/2018/11-2019-Missile-Defense-Review/The%202019%20MDR_Executive%20Summary.pdf.
38. U.S. Department of Defense, Joint Intelligence (Washington, DC: U.S. Department of Defense, 2013), I-6, fig. I-3, https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp2_0.pdf.
39. Recognizing that the Indian military may not use this intelligence process, but that any Indian intelligence process is likely to be based on the same theoretical underpinnings.

illustrate the disposition of Pakistan's nuclear forces, especially mobile systems operating from known, fixed locations. In response, the Pakistani military would likely seek to disperse these nuclear systems, including TELs and aircraft, much sooner and keep them mobile. This has been implied by the emphasis on nuclear force mobility by Pakistan's Inter Services Public Relations organization.[40] This would keep them moving faster than intelligence could be collected, undermining the ATR technologies and maintaining the forces' concealment. This would maintain India's uncertainty about potential costs, thus strengthening nuclear deterrence. However, the required pre-delegation of release authority, reduced security of the weapons, and vulnerability to accidents during transport could all undermine nuclear stability. In a crisis, these measures could also be seen as a significant escalation or as a precursor to a pre-emptive nuclear strike.

Alternatively, with future developments in satellite coverage and intelligence collection, persistent and high-quality intelligence collection might become the norm. In this case, with concealment a risky proposition for protecting nuclear systems, Pakistan may feel compelled to keep its land-based nuclear weapons closer to hardened facilities to maintain their survivability in the face of a first strike. This would be damaging to the nuclear deterrence relationship as they could be targeted more easily than a wide dispersion throughout the country. Neither scenario is ideal for Pakistan, but with only a limited number of options for maintaining the survivability of its ground-based deterrent, jeopardizing some concealment in order to maximize readiness may be necessary. Pakistan could also revert more toward an early-use nuclear doctrine, sometimes referred to as the hair-trigger alert, which would be tremendously destabilizing but significantly increase the costs of action for any Indian operation. This would also be true if, instead of relying on concealment in remote areas, Pakistan staged its forces closer to areas that would risk collateral damage to India, for instance in close proximity to the international border.

AI systems may also influence deterrence by changing the nature of rationality between India and Pakistan. Bounded rationality is academically favored as the basis for decisionmaking in a deterrence relationship. AI has the potential to change the bounds of rationality and subsequently affect psychological relationships, including deterrence. During the crisis in Pulwama, both the Indian and Pakistani decisionmakers only had limited intelligence to guide their actions. If AI was able to increase both the scale and responsiveness of intelligence collection, decisionmakers might be able to make more complex, informed decisions as they gain a more comprehensive and precise understanding of the strategic picture. Alternatively, decisionmakers may ascribe false levels of confidence to AI-enabled intelligence and make wrong decisions as a result. Either way, the bounds of rationality will be uniquely affected. Whether AI will introduce a step change in the speed or quality of decisionmaking remains debatable. The technology may make adversary assessments more complex by changing assumptions about strategic culture or psychological motivations. It may also make intelligence assessments easier, as decisionmakers' courses of action can be simulated and assessed for probability. However, ML-enabled decision support systems may also be subject to the same heuristics and biases as the designers of the system,[41] requiring a robust relationship between the programmers and analysts to ensure the decision support systems follow a sufficiently rigorous analytical process.

40. "No PR-94/2011-ISPR," Inter Services Public Relations (ISPR), April 19, 2011, https://www.ispr.gov.pk/press-release-detail.php?id=1721.
41. Richard Bettis and Songcui Hu, "Bounded Rationality, Heuristics, Computational Complexity and Artificial Intelligence," *Advances in Strategic Management* (September 2018): 139-150.

Recent works by Narang and Clary argue that developments in India's conventional capabilities may be intended to give India a pre-emptive or retaliatory counterforce capability.[42] The AI technologies described above could increase India's counterforce capabilities still further. Regardless of whether this was India's true goal, Pakistan might perceive the development of AI-based technologies alongside precision strike capabilities as designed to give India the capability to launch a disarming strike should a limited conventional conflict threaten to go nuclear. This would be consistent with many Pakistanis fears about India's alleged Cold Start strategy.[43] If Pakistan believed India was developing a counterforce posture strengthened by AI-based technologies, Pakistan would likely feel compelled to undertake measures to maintain or increase the survivability of its nuclear forces. In contrast, if an Indian counterforce posture was not credible, the introduction of AI-enabled tools by India might have follow-on implications for conventional military stability, which could disrupt the strategic balance between them.

The argument that India wishes to achieve strategic superiority by acquiring a counterforce capability is controversial. Sethi has argued by contrast that India has a basic philosophy regarding nuclear weapons that fundamentally precludes any move toward a counterforce doctrine.[44] This philosophy emphasizes a difference between nuclear and conventional weapons, in which nuclear weapons are exclusively a weapon of last resort and retaliation. While many Indian decisionmakers likely subscribe to this view, the fact remains that India is acquiring capabilities that lend themselves heavily to a counterforce posture, even if this is not the concerted government policy.[45] Regardless of the intent behind them, these capabilities have the potential to undermine Pakistan's confidence in the resilience of its nuclear capabilities. This would only be furthered by the procurement of ATR or ML-enabled decision support tools, which would address India's significant ISR shortfall.

SOCIAL VALUES AND ALGORITHM AVERSION

Outside of processing applications for AI, as considered above, another subset of AI technology has relevance to the nuclear domain. Decision support tools (as discussed in "What is artificial intelligence?" above) feed into human decisionmaking along with all other sources of information and advice. These risks can be unique to those posed by image recognition and intelligence collection. In most cases, analysts scrutinize information sources for accuracy and reliability to ensure later decisions are not made on circumstantial evidence. For an ML algorithm, both the training material and the input material (for subsequent analysis) should be scrutinized and validated. Then, by comparing the inputs with the outputs, the robustness of the system can be verified. Given the dependence of the ML agent on "clean" data, information security will become an increasingly pressing requirement for the operators. This is a cause for concern as the "intelligent" characteristic of the system may lull analysts or decisionmakers into a false sense of security in its conclusions, which is of concern for both conventional and nuclear decision support. This is also impacted by the unique social characteristics of the decisionmakers it supports and how trusting they are of automated systems in general. While constraints such as this may warrant the dismissal of decision support tools outright, Explainable AI (XAI) is being developed to make the process by which the tool

42. Christopher Clary and Vipin Narang, "India's Counterforce Temptations," *International Security* 43, no. 3, (Winter 2018/19): 7-52.
43. Walter C. Ladwig III, "A Cold Start for Hot Wars? The Indian Army's New Limited War Doctrine," *Quarterly Journal: International Security* 32, no. 3. (Winter 2007/08): 158-190.
44. Sethi, "Perceptions of India's Nuclear Capability Buildup."
45. Clary and Narang, "India's Counterforce Temptations."

reaches its conclusions more transparent.[46] It would be of the utmost importance that such a system was held to a high standard of assurance and reliability before being adopted. Anything less may lead to decisionmakers ascribing false confidence to the information they receive and making imperfect decisions that may escalate the situation in unexpected ways.

Decisionmakers may also be prone to "algorithm aversion," or the notion that inherent biases against (or for) the conclusions presented by an automated system may color their judgments. Some may dismiss these capabilities as being superficial or not technologically ready, while others may over exaggerate their potential or level of development. These are all potential risks for how AI may support decisionmaking but also opportunities should the limitations of the technology become more widely understood. Given the level of technological development within the field of AI, current research may benefit most from implementation, rather than continuing innovation. Research conducted on the characteristics of decisionmaking and decision support, especially in the context of AI, could be meaningfully applied to the strategic studies literature on deterrence and influence. As an example, literature is already emerging on how AI may change the nature of human psychology.[47] It is also worth considering how cultural factors within the AI itself, such as the assumptions made or training material used, might influence the nature of the decision support given. This will influence the degree to which the capability can be assured irrespective of the role in which it is eventually used.

HOW CAN STABILITY BE REINFORCED?

Symmetric or asymmetric capabilities could be obtained from third-party actors, such as China or the United States, to shore up (or further undermine) the strategic balance in the region. China may wish to preserve the current status quo and provide Pakistan with technologies to make its land-based missile forces more secure against intelligence collection and analysis. However, this raises the risk of destabilizing behaviors emerging between China and the United States, whereby they play out their rivalry by proxy on the subcontinent. Alternatively, Pakistan may take advantage of increasingly accessible open-source software or research to improve its own capabilities or conduct wargame-esque testing of its own survivability.

Pakistan could undermine ML-assisted intelligence analysis by disrupting the algorithm's inputs, using techniques such as deception and camouflage to undermine confidence in its outputs. This would undermine the strategic advantage that India would gain from the technology and thus redress the balance of power but not necessarily strengthen strategic stability. Stability would likely require willingness by India to come to the table, rather than relying on Pakistan to undermine India's advances. A number of studies have been conducted into how to deceive and undermine computer vision algorithms, or the training sets on which they rely. One could envision a cheap, rapidly erectable tarpaulin surrounding the TEL which gives it the appearance of an irregular polygon. There may be a number of other mitigation measures that are more responsive—and cheaper—than refining the algorithms and capabilities described in this essay. This could include interference through cyber means to take advantage of the distinct weaknesses of AI-enabled systems.

46. Matt Turek, "Explainable Artificial Intelligence," Defense Advanced Research Projects Agency, https://www.darpa.mil/program/explainable-artificial-intelligence.
47. Janna Anderson, Lee Rainie, and Alex Luchsinger, *Artificial Intelligence and the Future of Humans* (Washington DC: Pew Research Center, 2018) https://www.pewinternet.org/wp-content/uploads/sites/9/2018/12/PI_2018.12.10_future-of-ai_FINAL1.pdf.

By targeting the physical platforms and systems through which India would collect useful data, such as intelligence satellites, Pakistan could degrade the intelligence available for India to analyze. Dazzling satellites with lasers, jamming reconnaissance platforms, or using cyber means to disrupt the data collection, could disrupt the flow of information to Indian decisionmakers during a crisis and increase their level of uncertainty. This would increase other risks and is not necessarily indicative of a responsible state, but it may help safeguard a vulnerable nuclear deterrent. It also demonstrates the way in which emerging threats such as AI or cyber can overlap in both the offensive and defensive space. In a warfighting scenario where the nuclear deterrent was considered at risk, Pakistan could attack physical infrastructure directly by identifying Indian sites responsible for collecting and coordinating intelligence and striking them with cruise missiles or other means.

India and Pakistan could continue to explore mutual strategic stability initiatives such as the India-Pakistan Non-Attack Agreement, expanding the dialogue to cover emerging technologies. Signed in 1988, the agreement involves the annual sharing of lists of nuclear installations and facilities to build confidence between the two parties. While an exchange of information relating to disruptive systems may be too much to hope for, India could offer to limit the orbital tracks of its intelligence satellites in return for Pakistani concessions. This could allow for a degree of guaranteed concealment for Pakistan's nuclear weapons while allowing India to use this technology for conventional applications. Of course, this may encounter numerous objections from both sides. A more palatable option may be for Indian decisionmakers and senior leadership to reaffirm the No First Use pledge and make moves away from capabilities that enable, or appear to enable, nuclear counterforce operations.

LIMITATIONS AND RECOMMENDATIONS

Given the breadth of disciplines that have something to say about the relationship between emerging technologies, like AI and nuclear deterrence, an increasingly interdisciplinary approach to nuclear issues will be critical. The subject branches across so many different domains that to explore these issues in isolation is likely to miss a number of other relevant issues. While this article has highlighted some of the challenges AI will present for nuclear stability, there are also a number of options for how it could contribute to promoting stability. Public or open-source monitoring could be one potential option. Access to open-source imagery and the application of commercial algorithms could hold traditionally secretive nuclear command and posturing to greater account by allowing public scrutiny and reporting of nuclear activities. This article has also focused on the interaction between India and Pakistan as a fundamentally asymmetric relationship. However, the issue would also benefit from exploration in the context of Sino-Indian relations, especially given China's extensive investment and interest in AI, decisionmaking support, and applications to national security.

Without a background in the languages or cultures of South Asia, the material available to the author has been inevitably constrained. In spite of this, English language reporting of nuclear issues between India and Pakistan has been deemed sufficient enough by the author to allow for discussion of these issues, and any further foreign language sources could be expected to add further depth to the arguments rather than generate substantively different conclusions.

There are several avenues for future research in this area. The safeguards necessary to allow AI-enabled decision support tools to be used in sensitive fields would be one, while understanding the appetite for and awareness among senior decisionmakers of these tools would be another.

Furthermore, one could examine the applications of this technology to military decisionmaking at the operational level and how that may influence crisis stability. This could, for example, include indications of surprise attack or infiltration.

CONCLUSION

To conclude, there is a plausible argument that artificial intelligence could undermine Indo-Pakistan nuclear security irrespective of whether it is technologically mature because it could play into pre-existing Pakistani fears about alleged Indian desires for a counterforce capability. The implications of its potential can already influence the psychological relationship between Indian and Pakistani decisionmakers, much in the same way as the U.S. "Star Wars" program influenced Soviet assessments of the United States, often in counter-productive ways. The trend toward increasingly pervasive intelligence collection will threaten the concealment of Pakistan's nuclear forces, both at land and at sea. This will require Pakistan to undertake remedial measures such as active and passive ISR denial, dispersion of nuclear forces to increasingly hardened or unpalatable launch sites or increasing diversity and readiness of nuclear forces.

Given that AI capabilities will be introduced in a conventional role, if official statements and publications are to be believed, there are subsequent implications for both conventional and nuclear stability. Tests have already demonstrated the ability of ML-based systems to identify conventional TELs, and the next decade may introduce the ability for these systems to identify nuclear TELs and other assets and make recommendations based off the entirety of intelligence available to decisionmakers. The potential for this kind of disruption to the Indo-Pakistan nuclear relationship may lead India or Pakistan to take decisions that improve their respective nuclear capabilities, but which undermine strategic stability.

When considering strategic stability, it is also important to consider the cultural and human dynamics in particular contexts, as these will have a bearing on the deterrence relationship itself. As a result, progress in the field would benefit from interdisciplinary analysis, especially in the field of emerging technologies. This extends beyond both policy and technical knowledge, to sociological and psychological consideration.

Artificial Intelligence, the Final Piece to the Counterforce Puzzle?

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INTRODUCTION

It is widely expected that artificial intelligence (AI) will disrupt and fundamentally transform many aspects of social, economic, and political life over the coming decades.[2] As we are in the early stages of AI adoption in most fields, many discussions of its potential impact remain vague and superficial, including where national security is concerned.[3] Nevertheless, some scholars

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2. For the purposes of this study, I use "artificial intelligence"/"AI" to refer to the suite of machine-learning technologies that enable computer vision/automated image recognition (i.e., the automated identification and classification of objects from imagery data).

3. See Paige Gasser, Rafael Loss, and Andrew Reddie, "Assessing the Strategic Effects of Artificial Intelligence," (workshop presented at Lawrence Livermore National Laboratory, Livermore, CA, September 20-201, 2018), https://cgsr.llnl.gov/content/assets/docs/Final_AI_Workshop_Summary.pdf. For a comprehensive yet concise overview of the national security implications of AI, see Kelley M. Sayler, *Artificial Intelligence and National Security* (Washington, DC: Congressional Research Service, 2019), https://crsreports.congress.gov/product/pdf/R/R45178. Other relevant reports include Greg Allen and Taniel Chan, *Artificial Intelligence and National Security* (Cambridge, MA: Belfer Center for Science and International Affairs, 2017); JASON, *Perspectives on Research in Artificial Intelligence and Artificial General Intelligence Relevant to DoD* (McLean, VA: The MITRE Corporation, 2017); Edward Geist and Andrew J. Lohn, *How Might AI Affect the Risk of Nuclear War?* (Santa Monica, CA: RAND Corporation, 2018); Nicholas D. Wright, ed., *AI, China, Russia, and the Global Order: Technological, Political, Global, and Creative Perspectives* (Washington, DC: Department of Defense, 2018); and Vincent Boulanin, ed., *The Impact of Artificial Intelligence on Strategic Stability and Nuclear Risk, Volume I: Euro-Atlantic Perspectives* (Solna, Sweden: SIPRI, 2019).

have productively explored AI's impact on the character of warfare,[4] the balance of power among states,[5] and human society itself.[6] This article contributes to this growing body of literature by examining how this new technology might interact with one of the most prominent features of the post-World War II strategic environment: nuclear weapons. Specifically, it asks whether AI-driven improvements to intelligence, surveillance, and reconnaissance (ISR) capabilities (i.e., automated image recognition/computer vision) could enable an effective counterforce capability and thereby imperil nuclear deterrence and weaken first-strike stability.[7] Since the advent of the nuclear age, analysts have been divided over the meaning of nuclear weapons for international politics. Proponents of the "nuclear revolution" argue that nuclear weapons, particularly a secure second-strike capability, which would allow a state to retaliate with nuclear force after suffering a first strike, satisfy a state's security needs because they present a potential for unacceptable damage that would deter any potential challenger from even considering aggression.[8] In their view, international politics in the shadow of nuclear weapons would be largely peaceful, competition would be relegated to the margins, and nuclear superiority would be meaningless.[9] However, recent research suggests that this may not be the case. In fact, nuclear-weapon states have sought to hold at risk the nuclear arsenals of their adversaries throughout the nuclear age.[10] Still, no country has attacked another's operational nuclear arsenal.[11] That is because the requirements for a disarming strike are considerably higher than for damage limitation or retaliation against nuclear attack. A state trying to disarm its opponent would have to be certain to destroy, or at least disable, all of its adversary's nuclear weapons. Even one operational nuclear warhead could inflict unacceptable damage in a retaliatory blow. The inability to be certain that a first strike could find and eliminate all enemy nuclear weapons has been the main roadblock for effective counterforce.[12] As the number of battlefield sensors grows and ISR capabilities improve, however, this roadblock is crumbling. Some expect it to be fully overcome with the help of AI.

On February 11, 2019, President Donald Trump issued an executive order on "Maintaining American Leadership in Artificial Intelligence." Recognizing that "American leadership in AI is of paramount importance to maintaining the economic and national security of the United States and to shaping the global evolution of AI in a manner consistent with our Nation's values, policies, and priorities,"[13]

4. Mark Gilchrist, "Emergent Technology, Military Advantage, and the Character of Future War," *The Strategy Bridge*, July 26, 2018, https://thestrategybridge.org/the-bridge/2018/7/26/emergenttechnology-military-advantage-and-the-character-of-future-war.
5. Michael C. Horowitz, "Artificial Intelligence, International Competition, and the Balance of Power," Texas National Security Review 1, no. 3 (2018): 37-57.
6. Kenneth Payne, "Artificial Intelligence: A Revolution in Strategic Affairs?" *Survival* 60, no. 5 (2018): 7-32.
7. "Counterforce" is used to refer to a kinetic attack aimed at disarming an adversary's nuclear force. Per Glenn A. Kent and David E. Thaler, *First-Strike Stability: A Methodology for Evaluating Strategic Forces* (Santa Monica, CA: RAND Corporation, 1989), 2-3, "first-strike stability" refers to "a two-sided calculus of each side's cost of going first compared with its cost of striking second." Related to "crisis stability," which includes psychological and perceptional variables, first-strike stability solely "arises from the strategic force structure and the force postures within that force structure." Crisis stability and "arms-race stability" (i.e., absence of incentives to build up a nuclear force) are generally understood to be the co-determinants of overall "strategic stability."
8. Bernard Brodie, ed., *The Absolute Weapon: Atomic Power and World Order* (New York: Harcourt, 1946); Robert Jervis, *The Meaning of the Nuclear Revolution: Statecraft and the Prospect of Armageddon* (Ithaca: Cornell University Press, 1989).
9. Robert Jervis, "Cooperation Under the Security Dilemma," *World Politics* 30, no. 2 (1978): 167-214.
10. See Brendan R. Green and Austin Long, "The MAD Who Wasn't There: Soviet Reactions to the Late Cold War Nuclear Balance," *Security Studies* 26, no. 4 (2017): 606-41. For a more contemporary example, see Christopher Clary and Vipin Narang, "India's Counterforce Temptations: Strategic Dilemmas, Doctrine, and Capabilities," *International Security* 43, no. 3 (2019): 7-52.
11. On the use of preventive military force to destroy another country's nuclear program prior to it achieving a weapons capability, see Rachel Elizabeth Whitlark, "Nuclear Beliefs: A Leader-Focused Theory of Counter-Proliferation," *Security Studies* 26, no. 4 (2017): 545-74.
12. Jan Lodal, "The Counterforce Fallacy," *Foreign Affairs* 89, no. 2 (2010): 146.
13. "Executive Order on Maintaining American Leadership in Artificial Intelligence," White House, February 11, 2019, https://www.whitehouse.gov/presidential-actions/executive-order-maintaining-american-leadership-artificial-intelligence/.

it directed the Department of Defense (DoD) and other federal agencies to prioritize investments in AI research and development, high-performance computing, and an AI-versed workforce. DoD's own AI strategy subsequently detailed how the Pentagon views the particular risks and opportunities associated with advances in artificial intelligence.[14] DoD expects that AI will yield significant improvements for logistics, ISR, cyberspace and information operations, command and control, and semiautonomous and autonomous vehicles and weapon systems.[15] According to Deputy Secretary of Defense Robert Work, "what AI [...] allows you to do is find the needle in the haystack."[16] This ability of AI to quickly analyze enormous amounts of data could help identify, locate, target, and ultimately eliminate an adversary's nuclear arsenal.

The remainder of this article proceeds in four parts: First, it outlines the theoretical underpinnings of nuclear deterrence and the military requirements of counterforce before assessing the potential of AI to enable an effective counterforce capability. Drawing on work by Keir Lieber and Daryl Press,[17] a fictional North Korea scenario anchors this discussion in the second section and suggests that AI could improve to the ability to find and eliminate time-critical targets, such as mobile nuclear-missile launchers. The third section argues that these improvements remain marginal, as serious technical limitations inherent to AI prevent it from providing results that suffice for the requirements of counterforce.[18] Policymakers cannot gain certainty that a counterforce strike would fully eliminate an adversary's retaliatory capability. Finally, the article suggests that even these limited improvements in counterforce capabilities might negatively affect international stability. At least in some situations, AI-infused ISR could provide a "good enough" counterforce capability. If leaders believe that an enemy nuclear attack is imminent, for example, they might conclude that a pre-emptive counterforce strike is warranted to limit damage to their country and military assets. Furthermore, adversaries would face greater pressure to hedge against continued interest in counterforce options and improving capabilities. Some of their countermeasures would likely be detrimental for first-strike stability.

COUNTERFORCE IN THEORY AND (HYPOTHETICAL) PRACTICE

Much of the scholarly thinking on nuclear weapons evolved from Bernard Brodie's observation in August 1945 that the chief purpose of military force would no longer be to win wars, but to avert them.[19] Once the Soviet Union had developed nuclear weapons too, a "balance of terror" emerged.[20]

14. Department of Defense, *Summary of the 2018 Department of Defense Artificial Intelligence Strategy*, (Washington, DC: Department of Defense, 2019), https://media.defense.gov/2019/Feb/12/2002088963/-1/-1/1/SUMMARY-OF-DOD-AI-STRATEGY.PDF; see also Department of Defense, *2018 National Defense Strategy Summary* (Washington, DC: Department of Defense, 2018), https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.
15. See Sayler, *Artificial Intelligence and National Security*, 9-15.
16. Phil Stewart, "Deep in the Pentagon, a Secret AI Program to Find Hidden Nuclear Missiles," Reuters, June 5, 2018, https://www.reuters.com/article/us-usa-pentagon-missiles-ai-insight/deep-in-the-pentagon-a-secret-ai-program-to-find-hidden-nuclear-missiles-idUSKCN1J114J. See also "Memorandum on the Establishment of the Joint Artificial Intelligence Center," Department of Defense, June 28, 2018, https://admin.govexec.com/media/establishment_of_the_joint_artificial_intelligence_center_osd008412-18_r....pdf.
17. Keir A. Lieber and Daryl G. Press, "The New Era of Counterforce: Technological Change and the Future of Nuclear Deterrence," *International Security* 41, no. 4 (2017): 9-49.
18. These come in addition to the challenges presented by AI's integration into the intelligence processes to gather, process, exploit, and disseminate products as well as general targeting-timeline constraints.
19. See Brodie, *The Absolute Weapon*, 76.
20. Even among the group of civilian nuclear strategists who gathered at the RAND Corporation in the 1950s and 1960s, which comprised of Brodie, Herman Kahn, Thomas Schelling, Albert and Roberta Wohlstetter, and others, no consensus emerged on how delicate this balance was. For a critique of the assumption that general thermonuclear war is extremely unlikely, see Albert Wohlstetter, *The Delicate Balance of Terror* (Santa Monica, CA: RAND Corporation, 1958), https://www.rand.org/pubs/papers/P1472.html. For an intellectual history of RAND's contributions to deterrence theory, see Austin Long, *Deterrence* –

And as the superpowers' nuclear arsenals expanded—to comprise of the triad of ground-, air-, and sea-launched weapons—Brodie argues, "no sensible opponent would try to eliminate our ICBMs in an initial attack unless he believed that he could at the same time with high confidence eliminate by far the major portions of our other retaliatory forces."[21] This insight led some scholars to conclude that international relations had been fundamentally transformed. In a seeming reversal of logic, offensive strategic nuclear weapons provided states with the ultimate defense.[22] By threatening unimaginable devastation, nuclear powers could deter their adversaries from aggression. During the Cold War, the United States' and Soviet Union's expansive and secure second-strike retaliatory capabilities produced the supposedly stabilizing and largely irrevocable condition known as "mutual assured destruction" (MAD),[23] contributing, according to historian John Lewis Gaddis, to the "long peace" of the later twentieth century.[24] Yet, despite their considerable investments in survivable nuclear forces, the superpowers' nuclear doctrines did not conform to the prescriptions of nuclear revolution theory. "Rather than coming to grips with" MAD, they sought "to repeal the nuclear revolution"[25] and acquired nuclear warfighting capabilities beyond those necessary to threaten each other's population centers. When arms control treaties enshrined limitations and quantitative parity in the later stages of the Cold War, the superpowers competed for qualitative advantages.[26]

Deterrence remains only one of several roles that states envision for their nuclear forces. In order to hedge against future uncertainty and deterrence failure, U.S. doctrine, for example, assigns a damage-limitation role. This requires the ability to hold at risk adversary nuclear forces so that when deterrence fails, damage to the homeland can be minimized by destroying as many adversary nuclear weapons as possible.[27] Some have also suggested that such a posture might improve a nuclear weapon state's position in crisis bargaining by providing the nuclear-superior state with an advantage in resolve.[28] Moreover, with growing sophistication, counterforce capabilities could

From Cold War to Long War: Lessons from Six Decades of RAND Research (Santa Monica, CA: RAND Corporation, 2008).

21. Bernard Brodie, "The Development of Nuclear Strategy," *International Security* 2, no. 4 (1978): 71.

22. Jervis, *The Meaning of the Nuclear Revolution*, 1; and Charles L. Glaser, *Analyzing Strategic Nuclear Policy* (Princeton, NJ: Princeton University Press, 1990), 94-9.

23. See Spurgeon M. Keeny and Wolfgang K. H. Panofsky, "MAD versus NUTS: Can Doctrine or Weaponry Remedy the Mutual Hostage Relationship of the Superpowers?" *Foreign Affairs* 60, no. 2 (1981): 287-304.

24. John L. Gaddis, "The Long Peace: Elements of Stability in the Postwar International System," *International Security* 10, no. 4 (1986): 99-142.

25. Robert Jervis, *The Illogic of American Nuclear Strategy* (Ithaca, NY: Cornell University Press, 1984), 147. Joshua Rovner contends that rather than proving wrong the theory of the nuclear revolution, the apparent mismatch between historical record and theoretical prescriptions should motivate more nuanced theorizing: a more fine-grained "strategy-grand strategy distinction helps us understand the impact of nuclear weapons in the Cold War, and it provides a new way to evaluate the theory of the nuclear revolution." Joshua Rovner, "Was There a Nuclear Revolution? Strategy, Grand Strategy, and the Ultimate Weapon," War on the Rocks, March 6, 2018, https://warontherocks.com/2018/03/was-there-a-nuclear-revolution-strategy-grand-strategy-and-the-ultimate-weapon/.

26. Examples include Green and Long, "The MAD Who Wasn't There;" Austin Long and Brendan R. Green, "Stalking the Secure Second Strike: Intelligence, Counterforce, and Nuclear Strategy," *Journal of Strategic Studies* 38, no. 1-2 (2015): 38-73; and Niccolò Petrelli and Giordana Pulcini "Nuclear Superiority in the Age of Parity: US Planning, Intelligence Analysis, Weapons Innovation and the Search for a Qualitative Edge 1969–1976," *International History Review* 40, no. 5 (2018): 1191-209.

27. According to the latest Nuclear Posture Review, "Every U.S. administration over the past six decades has called for flexible and limited U.S. nuclear response options, in part to support the goal of reestablishing deterrence following its possible failure. This is not because reestablishing deterrence is certain, but because it may be achievable in some cases and contribute to limiting damage, to the extent feasible, to the United States, allies, and partners. The goal of limiting damage if deterrence fails in a regional contingency calls for robust adaptive planning to defeat and defend against attacks […] In the case of missile threats from regional actors in particular, U.S. missile defense and offensive options provide the basis for significant damage limitation in the event deterrence fails." Department of Defense, *2018 Nuclear Posture Review*, 23. See also Department of Defense, *2019 Missile Defense Review* (Washington, DC: Department of Defense, 2019), 60, https://www.defense.gov/Portals/1/Interactive/2018/11-2019-Missile-Defense-Review/The%202019%20MDR_Executive%20Summary.pdf.

28. See Matthew Kroenig, "Nuclear Superiority and the Balance of Resolve: Explaining Nuclear Crisis Outcomes," *International Organization* 67, no. 1 (2013): 141-71.

negate the threat of nuclear retaliation by enabling a disarming first strike against a nuclear-armed rival.[29]

Whether a counterforce capability is supposed to facilitate crisis bargaining, damage limitation, or disarming first strike, a key requirement for holding at risk adversary nuclear forces is to know where they are at a particular point in time.[30] This is no easy task. During Operation Desert Storm in 1991, coalition forces conducted roughly 1,500 air strikes over the course of the 43-day campaign to destroy Iraq's mobile Scud launchers. Yet, the Gulf War Air Power Survey concluded:[31]

> The actual destruction of any Iraqi mobile launchers by fixed-wing coalition aircraft remains impossible to confirm. Coalition aircrews reported destroying about eighty mobile launchers. Special operations forces claimed another score or so. Most of these reports undoubtedly stemmed from attacks that did destroy objects in the Scud launcher area. But most, if not all, of the objects involved now appear to have been decoys, vehicles such as tanker trucks that had infrared and radar signatures impossible to distinguish from those of mobile launchers and their associated support vehicles, and other objects unfortunate enough to provide 'Scud-like' signatures.

Iraq's adoption of shoot-and-scoot tactics, employing mobile transport-erector-launchers (TELs) to fire the missiles, contributed to the coalition's meager results. Additionally, the Scud crews relied on camouflage, concealment, and other deception techniques to keep their assets safe. This illustrates the staggeringly difficult challenge of finding and eliminating mobile, time-critical targets in even a largely uncontested environment. In the 2003 Iraq War, accordingly, U.S. forces went at great length to better perform in a repeat Scud hunt:[32]

> A tactical ballistic missile intelligence federation made up of fifteen different intelligence agencies and operational commands combined to do the intelligence preparation of the battlespace for Operation Iraqi Freedom. Potential launch areas or "Scud baskets" were identified. Geospatial data and analysis was generated to identify roads and paths Scud transporter-erector-launchers might traverse or potential hide sites. Intelligence on the potential Iraqi missile order of battle were combined with named areas of interest, coordinates were assigned, and "kill boxes" were identified and plotted. Then, had an engagement with Iraqi Scud transporter-erector-launchers taken place in Operation Iraqi Freedom (OIF), the triad of intelligence, surveillance, and

29. Lieber and Press, "New Era of Counterforce," 9. The question of whether the United States in the later Cold War seriously pursued a "splendid" first-strike capability (i.e., the ability to completely destroy an opponent's nuclear arsenal in a first strike) remains debated, although Fred Kaplan provides insights into deliberations among U.S. leaders of a first strike against Soviet nuclear forces in the context of the 1961 Berlin crisis. Fred Kaplan, "JFK's First-Strike Plan," *Atlantic*, October 2001, https://www.theatlantic.com/magazine/archive/2001/10/jfks-first-strike-plan/376432/.

30. According to Lieber and Press, the new era of counterforce is being brought about by two compounding trends: increasing accuracy of nuclear delivery systems and improvements in remote sensing. These developments erode states' ability to enhance the survivability of their nuclear forces through hardening and concealment respectively. While this article focuses on the revolution in remote sensing, specifically AI-infused ISR, improved missile accuracy might be consequential: "As accuracy continues to improve, the effectiveness of conventional attacks on hard targets will continue to increase. Today, low-yield nuclear weapons can destroy targets that once required very large yield detonations. In the future, many of those targets will be vulnerable to conventional attacks." With fewer expected casualties, decisionmakers might be more willing to strike adversary nuclear arsenals. Lieber and Press, "New Era of Counterforce," 32.

31. Thomas A. Keaney and Eliot A. Cohen, *Gulf War Air Power Survey, Summary Report* (Washington, DC: U.S. Government Printing Office, 1993), 83.

32. Barry R. Schneider, *Counterforce Targeting Capabilities and Challenges, USAF Counterproliferation Center Paper No. 22* (Maxwell AFB, AL: Air University, 2004), 18. See also Alan J. Vick et al., *Aerospace Operations Against Elusive Ground Targets* (Santa Monica, CA: RAND Corporation, 2001).

reconnaissance, special operations forces, and attack platforms would have combined to attempt to destroy the Scud threat.

While these improvements were not put to the test as no Iraqi Scuds surfaced during the campaign, U.S. forces likely would have fared better than a decade earlier.[33] Additional capabilities that have since been integrated into the armed forces have further increased the ability to surveil the battlefield. In 2003, for example, unmanned aerial systems (UAS) were a relative novelty.[34] They since have matured and arguably become the keystone for U.S. operations worldwide.

However, with the enormous growth of sensors and data sources across all warfighting domains,[35] intelligence analysts today struggle with an overabundance of information. In the words of Deputy Secretary of Defense Robert Work, Project Maven, perhaps the best-known example of the use of AI in a warfighting domain, was born out of this realization and intended to "reduce the human factors burden of [full-motion video] analysis, increase actionable intelligence, and enhance military decision-making" in support of the Defeat-ISIS campaign.[36] Frontline accounts also demonstrate the potential utility of AI as a force-multiplier. One former Marine artillery officer recounts the months spent developing a target list for strikes against ISIS weapon storage facilities in western Iraq in 2016: "Currently, both information collection and processing are manual, labor-intensive endeavors. AI can relieve human operators of much of that burden, performing the same tasks better and faster [...] and it will allow the military to increase its competitive advantage against both near-peer and non-state adversaries."[37] Following the first successes with Project Maven, DoD announced that the effort to integrate AI for warfighting would be expanded to include additional sensor types and use cases.[38] With its requirement to find and identify mobile, time-critical targets, the counterforce puzzle presents one such use case.

COUNTERFORCE IN A KOREA CONTINGENCY

To illustrate how advances in remote sensing could threaten the survivability of nuclear forces, Lieber and Press use a fictional scenario in which U.S. and partner forces attempt to find and track North Korean road-mobile missile launchers.[39] They argue that a combination of satellites and UAS

33. Long and Green, "Stalking the Secure Second Strike," 58-60, point to six other factors making the 1991 Scud hunt an ill-fitting analogy and "distant data point from a technology perspective" for modern mobile ICBM scenarios.
34. Schneider, "Counterforce Targeting," 19.
35. Lieber and Press identify five trends that are "ushering in an age of unprecedented transparency" and provide analysts with ever-growing amounts of data: increasingly diverse sensor platforms, a widening array of signals collected by such platforms, increasingly persistent observation, improvements in sensor resolution, and increasing data transmissions speeds. Lieber and Press, "New Era of Counterforce," 32-34.
36. "Memorandum on the Establishment of an Algorithmic Warfare Cross-Functional Team (Project Maven)," Department of Defense, April 26, 2017, https://www.govexec.com/media/gbc/docs/pdfs_edit/establishment_of_the_awcft_project_maven.pdf.
37. Hans Vreeland, "Targeting the Islamic State, or Why the Military Should Invest in Artificial Intelligence," War on the Rocks, May 16, 2019, https://warontherocks.com/2019/05/targeting-the-islamic-state-or-why-the-military-should-invest-in-artificial-intelligence/.
38. Mark Pomerleau, "What the Pentagon is Learning from its Massive Machine Learning Project," C4ISRNET, May 2, 2018, https://www.c4isrnet.com/intel-geoint/isr/2018/05/02/what-the-pentagon-is-learning-from-its-massive-machine-learning-project/.
39. Lieber and Press, "New Era of Counterforce," 37-46. Per Department of Defense, *2018 Nuclear Posture Review*, 23, the United States is committed to "locate, track, and target mobile systems of regional adversaries." For current U.S. doctrine for joint operations to counter air and missile threats, see Joint Chiefs of Staff, *Joint Publication 3-01: Countering Air and Missile Threats* (Washington, DC: 2018), https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp3_01_pa.pdf?ver=2018-05-16-175020-290. For illustrative examples of how a crisis on the Korean Peninsula might escalate to and beyond the nuclear threshold, see Mark Bowden, "How to Deal with North Korea: There Are no Good Options. But Some Are Worse than Others," *Atlantic*, July/August 2017, https://www.theatlantic.com/magazine/archive/2017/07/the-worst-problem-on-earth/528717/; Robin Wright, "What Would War with North Korea Look Like?" *New Yorker*, September 6, 2017, https://www.

could surveil almost the entirety of North Korea's road network, promising that its TELs would be detected by the sensors with high probability. They focus on three particular ISR platforms: satellites and standoff and penetrating UAS, equipped with synthetic aperture radar (SAR) and Ground Moving Target Indicator (GMTI) radar.[40]

North Korea is estimated to possess a stockpile of up to 60 nuclear warheads, with a capacity to produce an additional 7 warheads per year.[41] It also possesses an array of TEL-based short-range, medium-range, intermediate-range, and intercontinental ballistic missile (ICBM) systems on which to mount these warheads.[42] With its antiquated air force and a submarine force tailored to coastal defense, infiltration, and espionage missions, North Korea adopted land-based ballistic missiles as the most cost-effective and survivable option among available delivery system for its nascent nuclear force.[43] A long-standing reliance on the Korean People's Army Ground Force as its main service branch and its experience with artillery and ballistic missiles also contributed to North Korea's decision to prioritize a land-based nuclear force. Its small territory and challenging geography, further, led it to opt for mobile delivery systems operating from underground facilities over fixed, hardened silos. While mobile missiles were an effective response to the increasing accuracy of precision-strike weapons in the later decades of the twentieth century, mobile systems face several constraints, including geographical restrictions, outsized alert signatures, and high operational demands.[44] These are at risk of being exploited by the sensing revolution, making mobile systems, too, vulnerable to counterforce attacks.

While in peacetime North Korea's nuclear weapons are likely located in underground storage facilities, possibly even in a disassembled state to exert maximum central control by the supreme leader, the TELs would be dispersed in a crisis to enhance their survivability and facilitate North Korea's "asymmetric escalation" strategy to deter invasion and/or compel concessions.[45] In recent years, nongovernmental analysts have used open-source and commercial satellite photographs

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newyorker.com/news/news-desk/what-would-war-with-north-korea-look-like; and Jeffrey Lewis, *The 2020 Commission Report on the North Korean Nuclear Attacks Against the United States: A Speculative Novel* (Boston, MA: Mariner Books, 2018).

40. For information on the use of SAR and GMTI in military space radar systems, see Joseph Post and Michael Bennett, Alternatives for Military Space Radar (Washington, DC: Congressional Budget Office, 2007).

41. Mary Beth D. Nikitin, *North Korea's Nuclear and Ballistic Missile Programs* (Washington, DC: Congressional Research Service, 2019), https://crsreports.congress.gov/product/pdf/IF/IF10472.

42. Hans M. Kristensen and Robert S. Norris, "North Korean Nuclear Capabilities, 2018," *Bulletin of the Atomic Scientists* 74, no. 1 (2018): 41-51.

43. See James Hackett and Mark Fitzpatrick, *The Conventional Military Balance on the Korean Peninsula* (London, UK: International Institute for Strategic Studies, 2018). On North Korea's efforts to diversify its nuclear launch platforms and operationalize a sea-based deterrent capability, see also Ankit Panda, "The Sinpo-C-Class: A New North Korean Ballistic Missile Submarine Is Under Construction," *Diplomat*, October 18, 2017, https://thediplomat.com/2017/10/the-sinpo-c-class-a-new-north-korean-ballistic-missile-submarine-is-under-construction/. For why North Korea might be at a comparative disadvantage in developing a survivable sea-based deterrent, see Owen R. Coté, "Invisible Nuclear-Armed Submarines, or Transparent Oceans? Are Ballistic Missile Submarines Still the Best Deterrent for the United States?" *Bulletin of the Atomic Scientists* 75, no. 1 (2019): 30-5.

44. See Paul Bracken, "The Cyber Threat to Nuclear Stability," *Orbis* 60, no. 2 (2016): 192-97.

45. See Van Jackson, "What Is North Korea's Nuclear Strategy?" *Diplomat*, May 28, 2015, https://thediplomat.com/2015/05/what-is-north-koreas-nuclear-strategy/; Vipin Narang, "Why Kim Jong Un Wouldn't Be Irrational to Use a Nuclear Bomb First," *Washington Post*, September 8, 2017, https://www.washingtonpost.com/outlook/why-kim-jong-un-wouldnt-be-irrational-to-use-a-nuclear-bomb-first/2017/09/08/a9d36ca4-934f-11e7-aace-04b862b2b3f3_story.html; Vipin Narang and Ankit Panda, "Command and Control in North Korea: What a Nuclear Launch Might Look Like, Like," War on the Rocks, September 15, 2017, https://warontherocks.com/2017/09/command-and-control-in-north-korea-what-a-nuclear-launch-might-look-like/; and Joseph Bermudez, Victor Cha, and Lisa Collins, "Undeclared North Korea: Missile Operating Bases Revealed," *Beyond Parallel*, Center for Strategic and International Studies, November 12, 2018, https://beyondparallel.csis.org/north-koreas-undeclared-missile-operating-bases/. On the evolution of North Korean thinking about nuclear strategy, see Joseph S. Bermudez, Jr., *North Korea's Development of a Nuclear Weapons Strategy* (Washington, DC: US-Korea Institute at SAIS, 2015).

to identify many of North Korea's missile bases and likely launch sites.[46] U.S. intelligence agencies almost certainly have even more detailed information about the deployment patterns of North Korean nuclear forces. In a crisis situation though, U.S. ISR assets would be critical for finding and tracking North Korea's TEL-based nuclear weapons in real time.[47]

Based on geospatial analysis, Lieber and Press argue that an array of 20 SAR satellites could provide coverage of at least 90 percent of North Korea's roads on as many as 50 passes per day. An additional four standoff SAR/GMTI UAS and four penetrating UAS, if positioned correctly, could provide persistent coverage of approximately 97 percent of the road network. Moreover, since the U.S. ISR arsenal includes many more assets, such as cyber-spying/-intelligence, ground-based sensors, and satellites and UAS scanning other parts of the electromagnetic spectrum, they conclude that "concealment is under great duress."[48] However, their analysis excludes the process of generating actionable intelligence from data captured by the sensors. It instead assumes that North Korean TELs that are captured by satellites and UAS are also identified and classified as targets for counterforce strikes and therefore at risk. While imposing this restriction makes sense to simplify analysis and highlight the *potential* for advances in remote sensing to undermine concealment, it underappreciates the challenge of drawing conclusions from raw data. In an escalating crisis on the Korean Peninsula, U.S. forces would likely leverage more than just eight UAS and the occasional satellite overpass for intelligence preparation of the battlespace.[49] The input from the ever-expanding number of sensors, however, could quickly overwhelm analysts in their task to identify, classify, and cue potential time-critical targets.

HOLD YOUR AI-INFUSED COUNTERFORCE HORSES

AI promises to increase operational tempo and decrease uncertainty in combat environments where "speed is paramount, and the fog of war persists."[50] Similar to the way Project Maven helps analyze imagery data in support of the Defeat-ISIS campaign, AI could prove decisive in a North Korea contingency by improving the ability to promptly analyze sensor data for identifying and tracking North Korea's TEL-based nuclear force. Despite this broad and growing enthusiasm for military applications of AI—including AI-infused ISR for counterforce missions[51]—it is unlikely to prove revolutionary. Technical limitations prevent even AI-enabled counterforce from guaranteeing success. AI could also introduce new vulnerabilities into ISR systems for adversaries to exploit. Faulty assumptions derived from previous technological innovations, moreover, could lead decisionmakers to be overly optimistic about the improvements to counterforce yielded by AI, leading to misinformed decisions over the use of military force.[52]

46. See, for example, the work conducted by Beyond Parallel at the Center for Strategic and International Studies, available at https://beyondparallel.csis.org/imagery/, and 38 North at the Henry L. Stimson Center, available at https://www.38north.org/topics/satellite-analysis/.
47. On damage limitation/counterforce vis-à-vis North Korea, see John R. Harvey, "Negating North Korea's Nukes," *Defense News*, February 15, 2016, https://www.defensenews.com/opinion/commentary/2016/02/15/commentary-negating-north-koreas-nukes/; and Vince A. Manzo and John K. Warden, "The Least Bad Option: Damage Limitation and U.S. Deterrence Strategy toward North Korea," T*exas National Security Review* Policy Roundtable, February 07, 2018, https://tnsr.org/roundtable/policy-roundtable-good-choices-comes-north-korea/#essay6.
48. Lieber and Press, "New Era of Counterforce," 48. See also Long and Green, "Stalking the Secure Second Strike," 60-4.
49. For the potential nuclear-stability implications of other emerging technologies, particularly private-sector innovation in big-data analytics, such as pattern recognition, system visualization, and predictive analytics, see Bracken, "Cyber Threat," 197-99.
50. Vreeland, "Targeting the Islamic State."
51. See Stewart, "Deep in the Pentagon."
52. See Joseph Johnson and Rafael Loss, "Artificial Intelligence Will Not Imperil Nuclear Deterrence," War on the Rocks, September 19, 2019, https://warontherocks.com/2019/09/will-artificial-intelligence-imperil-nuclear-deterrence/. For a deeper technical analysis of the limitations of automated image recognition, see Joseph Johnson, *MAD in an AI Future?* (Livermore, CA: Lawrence Livermore National Laboratory, 2019), https://cgsr.llnl.gov/content/assets/docs/MAD-in-an-AI-Future.pdf.

Machine-learning algorithms for computer vision rely on input data for training and reliable object recognition. As discussed above, these can be provided by a multitude of different sensor platforms. The task of the AI would be to identify TELs among objects that are not mobile missile launchers. One challenge AI would encounter is the dataset imbalance—a challenge in classification problems called "class imbalance"—between "ground truth" pictures of TELs and pictures of other, similar military and non-military (non-TEL) vehicles. While relatively few would be available of the former, there is an abundance of the latter. An AI might then be incentivized "to increase its accuracy by rarely or never identifying a mobile launcher," producing false negatives.[53] Manually generating additional synthetic versions of TEL images to increase sample size, on the other hand, could lead to false positives as some non-TEL vehicles could be misclassified for their resemblance with synthetic TELs. More fundamental though, pictures are a poor representation for what really differentiates vehicles: their role and function.[54] While humans can induce function from the observable characteristics of a particular vehicle, AI's ability to do so remains limited. Relatedly, the "curse of dimensionality" prevents AI from reliably understanding objects as the number of discernable features grows.[55] Attempting to compensate for the shortcomings of satellite imagery by increasing resolution or generating three-dimensional models of objects of interest would not only require exponentially more memory and running time, but it would also make similar pictures seem increasingly dissimilar and vice versa because of AI's inability to discard the irrelevant information contained in images with higher resolution.[56]

Could future improvements to AI resolve these shortcomings? While not entirely implausible, machine-learning theory cautions against exaggerated optimism. For once, AI designers face a bias/variance tradeoff when deciding which data an algorithm should base its decisions on, leading to an irreducible error when working with imperfect—that is, most—measurements of reality.[57] Tradeoffs also exist between different AI algorithms. As of now, there is no one algorithm that can outperform all other algorithms—many with an infinite number of possible variations—at all possible problem sets.[58] Even if an algorithm performed perfectly in the past, for example, in TEL-hunt simulations, perfect performance in the future, confronted with previously unknown data or the real world, cannot be guaranteed.[59] No AI could therefore assure a fully effective counterforce strike in an operational context; some uncertainty would always remain. Moreover, the strategic nature of military affairs makes it difficult to tailor algorithms for better performance.[60] Adversaries are incentivized to try to beat the AI with creative concealment efforts. Alternatively, they could attempt to poison the AI's training data so that it produces false results in the field, which could lead to consequential misclassification of targets. Ultimately, the performance of any AI cannot be validated without application to the problem it is designed to tackle in the field.[61] However, inherent to validating AI-supported counterforce in the real world is the risk of nuclear escalation.

53. Ibid., 4.
54. Ibid., 5.
55. Pedro Domingos, "A Few Useful Things to Know About Machine Learning," *Communications of the ACM* 55, no. 10 (2012): 82-3.
56. Johnson, *MAD in an AI Future?*, 5-6.
57. Domingos, "A Few Useful Things to Know," 81-2.
58. See David H. Wolpert, "The Lack of A Priori Distinctions Between Learning Algorithms," *Neural Computation* 8 (1996), 1341–1390.
59. Johnson, *MAD in an AI Future?*, 7.
60. Yann LeCun, "Generalization and Network Design Strategies," *Connectionism in perspective* 19 (1989), 143, observes "that good generalization performance on real-world problems cannot be achieved unless some *a priori* knowledge about the task is built into the system." The strategic and dynamic nature of the counterforce problem, however, limits the ability to gain a priori knowledge and therefore hinders AI tailoring for better performance.
61. Johnson, *MAD in an AI Future?*, 8-9. On the difficulty of validating the real-world performance of military software technology, see also David Lorge Parnas and Danny Cohen, *SDI: Two Views of Professional Responsibility* (San Diego, CA: Institute on Global Conflict and Cooperation, 1987), 4-6.

Despite these challenges, faulty assumptions about AI continue to drive decisionmaking. These result primarily from misconceptions about the technical maturity of machine "reasoning" and misplaced expectations about the scalability of AI solutions. Confronted with impressive results, observers regularly ascribe human-level intelligence to algorithms.[62] This ignores the fundamentally different processes by which AI and humans acquire knowledge. While intuition, compositionality, and causal models (and learning-to-learn) allow humans to arrive at deep levels of understanding from relatively few data points,[63] even state-of-the-art machine learning algorithms "are not learning the true underlying concepts."[64] In narrowly-defined problems, AI has sometimes exceeded human performance. Lacking deep understanding, however, AI results mostly remain nontransferable to much different problem sets. This closely relates to the illusion of scalability. Unlike defense innovation in the physical world, which usually follows linear growth rates, tackling increasingly complex problems in the computational world often requires resource investments to grow exponentially.[65] To scale up AI solutions accordingly, efficiency must be attained at the expense of accuracy. An efficient solution could therefore not be guaranteed to be the "best" solution, and the best one not to be particularly efficient.[66]

In sum, technical limitations will constrain AI, for the foreseeable future, to operate at levels of confidence insufficient for problems as complex and dynamic as nuclear counterforce. Still, faulty assumptions derived from earlier military-technological innovation in the physical world continue to drive decisionmaking for the computational world. For competitive dynamics in international relations, however, perceptions of the U.S. pursuit of AI for military operations might be more important than their actual capabilities. From the perspective of adversaries, after all, the United States has an expressed interest in counterforce options and is investing substantial sums to improve its ability to hold at risk adversary arsenals, including through AI-infused ISR. The next section assesses some of the options adversaries like North Korea might pursue to hedge against improving U.S. counterforce capabilities.

HEDGING AGAINST THE GHOST OF COUNTERFORCE FUTURE

AI's independent impact on the ability to find and destroy nuclear weapons will remain limited.[67] Much of defense planning, however, is conservative and based on worst-case scenarios because of the high-risk nature of military affairs, especially in the nuclear realm.[68] The United States maintains the ICBM-leg of its nuclear triad partly out of concern that its submarine-launched weapons might one day become vulnerable.[69] China and Russia express concerns about U.S. ballistic missile defense not for the current state of these systems, but because improvements could eventually facilitate a surprise first strike and "mop up" any remaining warheads that were not destroyed in their silos.

62. For example, Stuart Armstrong, Kaj Sotala, and Seán S. Ó hÉigeartaigh, "The Errors, Insights and Lessons of Famous AI Predictions – and What They Mean for the Future," *Journal of Experimental & Theoretical Artificial Intelligence* 26, no. 3 (2014): 317-342, identifies a general overconfidence among experts concerning future AI developments.
63. See Brenden M. Lake et al., "Building Machines that Learn and Think Like People," *Behavioral and Brain Sciences* 40 (2017): 15-31.
64. Ian J. Goodfellow, Jonathon Shlens, and Christian Szegedy, "Explaining and Harnessing Adversarial Examples," *arXiv* (2014), 2.
65. Danko Nikolic, "The Challenge of Scaling AI Technology," DXC.technoloy Blog, April 27, 2017, https://blogs.dxc.technology/2017/04/27/the-challenge-of-scaling-ai-technology/.
66. Johnson, *MAD in an AI Future?*, 10.
67. For an assessment of the relative significance and contextual dependencies of emerging technologies in defense transformation more broadly, see Colin S. Gray, "Technology as a Dynamic of Defence Transformation," *Defence Studies* 6, no. 1 (2006): 26-51.
68. See Michael Fitzsimmons, "The Problem of Uncertainty in Strategic Planning," Survival 48, no. 4 (2006): 136-7.
69. Brad Roberts, *The Case for U.S. Nuclear Weapons in the 21st Century* (Stanford, CA: Stanford University Press, 2015), 269. See also Department of Defense, *2018 Nuclear Posture Review*, 43.

Russia, in particular, explains its investments in hypersonic and other advanced weapon systems in response to future U.S. missile-defense capabilities.[70] This is all despite a general understanding that missile defense as it stands today is unable to perform this role. Ultimately, adversaries should be expected to hedge against the dangers of a future in which AI will play a role in nuclear strategy, no matter how unlikely this application is today.

Facing improving counterforce capabilities and an expressed U.S. interest in counterforce options, what measures could North Korea take to enhance the survivability of its nuclear weapons? While some possible nuclear-posture adjustments would be unsuitable for a land-based force like North Korea's, others are more feasible.[71] Of these, however, the most effective measures are also those most likely to undermine first-strike stability, and opportunity costs abound.

The two Cold-War superpowers relied to a great extent on hardening to make their land-based nuclear forces more survivable. They placed their ICBMs in hardened silos and their strategic nuclear bombers in hardened hangers built to withstand surface and air bursts from near misses of enemy nuclear weapons. However, while hard to destroy, ICBM silos are easy to find.[72] All else being equal, against a smaller country like North Korea, relatively fewer nuclear weapons would suffice to destroy the same number of targets because of closer proximity between the silos. Additionally, improvements in weapons accuracy have made hardened weapons increasingly vulnerable as well, even to nonnuclear precision-strike attacks.[73] Accordingly, facing a much more expansive and sophisticated U.S. arsenal, moving toward a silo-based ICBM force would be a poor choice for North Korean leaders to make.

North Korea could also attempt to make its nuclear force harder to find by improving mobility and concealment. However, TELs will remain largely confined to roads. After all, ICBMs are bulky. Russia's road-mobile SS-27 "Sickle B," for example, measures around 22 meters in length with a diameter of approximately 2 meters, weighing 47,000 kg.[74] North Korea's Hwasong-15, which was flight-tested on November 29, 2017, is estimated to be of similar proportions.[75] The 9-axle TEL this missile is transported on is unable to navigate much of the country's difficult terrain; "The belief that mobile missiles can be transported off road and on, and can be made operational in a short time, is an illusion."[76] This funnels TELs into identifiable areas of operation (i.e., the North Korean road network). Their logistics tails further reduce mobile launchers' ability to move fast and undetected. Until ICBMs become significantly lighter and smaller, substantial mobility increases will remain out of reach.

70. George Lewis and Frank von Hippel, "Limitations on Ballistic Missile Defense—Past and Possibly Future," *Bulletin of the Atomic Scientists* 74, no. 4 (2018), 203-4; and Fiona S. Cunningham and M. Taylor Fravel, "Assuring Assured Retaliation: China's Nuclear Posture and U.S.-China Strategic Stability," *International Security* 40, no. 2 (2015): 16-9. On President Trump's ambition to "detect and destroy any missile launched against the United States — anywhere, anytime, anyplace," see "Remarks by President Trump and Vice President Pence Announcing the Missile Defense Review," White House, January 17, 2019, https://www.whitehouse.gov/briefings-statements/remarks-president-trump-vice-president-pence-announcing-missile-defense-review/. For a critique thereof, see Laura Grego, "No, Missile Defense Will Not Work 97% of the Time," *All Things Nuclear*, Union of Concerned Scientists, October 13, 2017, https://allthingsnuclear.org/lgrego/missile-defense-will-not-work-97-percent.
71. Per Vipin Narang, *Nuclear Strategy in the Modern Era: Regional Powers and International Conflict* (Princeton, NJ: Princeton University Press, 2014), 4, "nuclear posture" here refers to the capabilities, doctrine, and command-and-control procedures that constitute a state's nuclear weapons capability.
72. See Bracken, "Cyber Threat," 191.
73. Ibid., 192. See also Lieber and Press, "New Era of Counterforce," 18-32.
74. Missile Defense Project, "SS-27 'Sickle B' (RT-2PM2 Topol-M)," *Missile Threat*, Center for Strategic and International Studies, June 15, 2018, https://missilethreat.csis.org/missile/ss-27/.
75. Missile Defense Project, "Hwasong-15 (KN-22)," *Missile Threat*, Center for Strategic and International Studies, June 15, 2018, https://missilethreat.csis.org/missile/hwasong-15-kn-22/; and Michael Elleman, "The New Hwasong-15 ICBM: A Significant Improvement That May be Ready as Early as 2018," 38 North, November 30, 2017, https://www.38north.org/2017/11/melleman113017/.
76. Bracken, "Cyber Threat," 194.

Concealment may be the most promising path to make North Korea's land-based nuclear forces more survivable, and one that could leverage AI-specific countermeasures. For example, mobile missile teams can rely on presurveyed launch and hide sites equipped with camouflage tarps to protect their launchers from multispectral aerial reconnaissance.[77] To fool AI-infused ISR capability, it might even suffice to simply have alerted TELs look different from the imagery used to train the AI system on a particular mobile launcher by obscuring its observable characteristics or building "TEL-shells" to distract the AI with decoy vehicles resembling mobile-missile launchers. Because of the above-discussed bias/variance tradeoff, the AI might then not be able to reliably distinguish a TEL from a commercial truck. Adversaries might also attempt to implant faulty data in AI training datasets to introduce bias in an algorithm's developmental stage.[78] Imperceptible to humans, such inputs could dramatically alter the performance of AI, making it fail in unexpected and uninterpretable ways. As of now, there are few effective countermeasures to adversarial inputs.[79]

Concealment measures, too, come with costs, however. Extensive preparations and security at designated launch and hide sites might draw scrutiny. Moreover, command and control of nuclear forces require communication—for mobile systems more so than for fixed ones. While communication can be reduced to a minimum, if a launch order is to be transmitted, some open channel must be maintained. Its logistics tail further expands a TELs footprint. "Tells" of launch preparations or heightened alert status would likely be picked up by a variety of sensors.[80] Even if concealment can reliably fool AI-supported imagery analysis, other sensor platforms would still collect signals. Furthermore, attempts to implant adversarial data, for example through offensive cyber operations, risk detection and research efforts are underway to address AI's vulnerability to adversarial inputs.[81] Given the power and resource imbalance between those who can marshal counterforce capabilities and those who hedge against them—like the United States and North Korea, respectively—and the fact that leadership in sensing requires familiarity with potential countermeasures, however, the balance is likely to shift further in favor of great powers with counterforce ambitions.[82]

In addition to these technical adjustments to improve survivability, North Korea might also revise its nuclear weapons employment doctrine. Changes in employment doctrine are not so much about ensuring a retaliatory capability should North Korea suffer from a first strike as they are about enhancing the credibility that it would use its nuclear weapons in a conflict with the United States.[83] Because it cannot assure mutual destruction, North Korea would likely have to escalate to the nuclear level early in such a conflict. Its asymmetric escalation doctrine would draw on short-, medium-, and intermediate-range nuclear assets to stave off a conventional invasion while holding in reserve ICBMs

77. See Li Bin, "Tracking Chinese Strategic Mobile Missiles," *Science and Global Security* 15, no. 1 (2007): 10.
78. See, for example, Christian Szegedy et al., "Intriguing Properties of Neural Networks," *arXiv* (2013); and Ian Goodfellow, Patrick McDaniel, and Nicolas Papernot, "Making Machine Learning Robust Against Adversarial Inputs," *Communications of the ACM* 61, no. 7 (2018), 56-66. On cybersecurity risks and the hacking of nuclear weapons systems more broadly, see, for example, Andrew Futter, *Cyber Threats and Nuclear Weapons: New Questions for Command and Control, Security and Strategy* (London, UK: Royal United Services Institute, 2016), https://rusi.org/sites/default/files/cyber_threats_and_nuclear_combined.1.pdf; and Beyza Unal and Patricia Lewis, *Cybersecurity of Nuclear Weapons Systems: Threats, Vulnerabilities and Consequences* (London, UK: Chatham House, 2018), https://www.chathamhouse.org/sites/default/files/publications/research/2018-01-11-cybersecurity-nuclear-weapons-unal-lewis-final.pdf.
79. Goodfellow, McDaniel, and Papernot, "Making Machine Learning Robust," 65.
80. Bracken, "Cyber Threat," 196.
81. Goodfellow, McDaniel, and Papernot, "Making Machine Learning Robust," 66.
82. See Lieber and Press, "New Era of Counterforce," 46-7.
83. See Peter D. Feaver, "Correspondence: Proliferation Pessimism and Emerging Nuclear Powers," *International Security* 22, no. 2 (1997): 185–207.

to deter nuclear retaliation by threatening the U.S. homeland.[84] With improving U.S. counterforce capabilities, however, North Korea faces growing use-it-or-lose-it pressure.[85] In a crisis, North Korea would be incentivized to employ its weapons before a counterforce strike could degrade its nuclear capability.[86] North Korean concerns about the efficacy of U.S. missile defenses would further spur preemptive and massive launch; the larger the volley of incoming North Korean ICBMs, the greater the chance that at least one warhead would evade defenses.[87] While North Korea could not hope to make a dent in the U.S. nuclear retaliatory capability, its leaders might perceive a slim chance that the destruction of a major city might shatter U.S. resolve and compel it to stop fighting. The perception of being confronted with an AI-improved counterforce capability would shorten North Korea's timeline for effective nuclear employment. It would have to rely more extensively on pre-delegating launch authority, co-locating operational warheads and delivery systems, and maintaining a state of high alert to maintain a credible deterrent. However, in addition to growing risks of deliberate nuclear use, this would increase the probability of inadvertent and accidental employment. An otherwise containable crisis on the Korean peninsula could thus quickly spiral toward nuclear disaster.[88]

CONCLUSION

This article provides an assessment of whether AI enables states to conduct effective counterforce strikes against adversary nuclear arsenals. An effort was made to minimize abstraction by drawing on recent U.S. experiences with the application of AI to the Defeat-ISIS campaign, technical assessments of the vulnerabilities and limitations of current machine-learning technologies, and open-source material on North Korea's nuclear program, arsenal, and force posture. While this necessarily makes for an incomplete picture, it nevertheless suggests some preliminary conclusions about future, AI-infused counterforce capabilities and their effect on international stability.

This analysis has shown that AI can play a critical role in improving ISR for military operations. Since the failed Scud hunt of the 1991 Gulf War, U.S. armed forces have invested heavily in improving their ability to find, fix, and finish mobile missile launchers. More recently, AI has been leveraged to better make use of the expansive full-motion video imagery provided by UAS operating in the skies above Syria and Iraq. While in the past counterforce suffered from an inability to identify and track enemy TELs, these advances in AI-supported remote sensing could finally enable an effective counterforce

84. Narang, "Kim Jong Un Wouldn't Be Irrational." On the functional logic of asymmetric escalation, see also Narang, *Nuclear Strategy*, 19-21.
85. To assert, as Vince Manzo and John Warden do, that nuclear employment "is in no way a 'dominant strategic move' for North Korea" and therefore irrational, is an overly generous assumption about crisis decision making and the ability to control escalation in an ongoing conflict. See Vince Manzo and John Warden, "Want to Avoid Nuclear War? Reject Mutual Vulnerability with North Korea," War on the Rocks, August 29, 2017, https://warontherocks.com/2017/08/want-to-avoid-nuclear-war-reject-mutual-vulnerability-with-north-korea/. For a more complete picture, see, for example, Robert Jervis, "The Political Effects of Nuclear Weapons: A Comment," *International Security* 13, no. 2 (1988): 80-90; Barry R. Posen, *Inadvertent Escalation: Conventional War and Nuclear Risks* (Ithaca, NY: Cornell University Press, 1991); and Mark S. Bell and Julia Macdonald, "How to Think About Nuclear Crises," T*exas National Security Review* 2, no. 2 (2019): 40-65, https://tnsr.org/2019/03/how-to-think-about-nuclear-crises/.
86. For first-strike stability in the context of India-Pakistan and U.S.-China relations, see, respectively, Clary and Narang, "India's Counterforce Temptations;" and Caitlin Talmadge, "Would China Go Nuclear? Assessing the Risk of Chinese Nuclear Escalation in a Conventional War with the United States," *International Security* 41, no. 4 (2017): 50-92.
87. Ankit Panda and Vipin Narang, "Deadly Overconfidence: Trump Thinks Missile Defenses Work Against North Korea, and That Should Scare You," War on the Rocks, October 16, 2017, https://warontherocks.com/2017/10/deadly-overconfidence-trump-thinks-missile-defenses-work-against-north-korea-and-that-should-scare-you/.
88. Moreover, improving counterforce capabilities might spur arms races in peacetime with externalities reaching beyond the U.S.-North Korean nuclear competition. If the United States continued to seek the capabilities to hold at risk North Korean nuclear weapons and North Korea expanded its strategic nuclear arsenal to maintain survivability, its expanding arsenal would come to resemble that of China and Beijing might begin to perceive a threat to its nuclear deterrent. See Bin, "Tracking Chinese Strategic Mobile Missiles," 26.

capability. Should a crisis erupt on the Korean Peninsula, the United States' unparalleled military power and ISR capabilities equipped with AI would be more able than ever to find and destroy North Korea's road-mobile nuclear weapons. Or so some argue.

AI's true potential to revolutionize counterforce remains hampered by inherent flaws. These lie in the shortcomings of the data available to AI for both training and operationalization. Because of inherent limitations illustrated by machine-learning theory and adversary incentives to fool algorithms, future improvements should not be expected to perfect AI either. Faulty assumptions about the inner workings of artificial intelligence, however, lead policymakers to continue to overestimate the impact and potential of AI in military affairs and overlook its real limitations.

Thus, while there is demand for AI-infused ISR capabilities to improve target identification and elimination, including of adversary nuclear forces, supply will not satisfy the necessarily high requirements for perfection in counterforce. Yet, expressed U.S. interest in damage limitation and counterforce options, as well as AI's contribution to a marginally improving counterforce capability, provide powerful incentives for adversaries, like North Korea, to hedge by increasing the survivability of their nuclear forces and adjusting their employment doctrines. Such measures, particularly the pre-delegation of launch authority and co-location of operational warheads and delivery systems, however, would heighten the risk of inadvertent and accidental nuclear use during a crisis.

U.S. leaders should want to mitigate such risks. Yet, AI-infused ISR and greater effectiveness of nonnuclear weapons are tremendously useful for future military operations in the context of great-power competition. Neither can these efforts be siloed out of the counterforce complex, particularly from the point of view of adversaries. Even if U.S. counterforce capabilities are expressly not aimed at China or Russia but rather the product of damage-limitation requirements vis-à-vis North Korea, efforts to keep up with a gradually expanding North Korean nuclear arsenal might eventually encroach upon China's relatively small number of weapons as well. After all, states in competitive relationships care more about what others can *do* to them than what others say about their intentions. Thus, chances are that we have indeed entered a new era of counterforce, resulting in greater instability among nuclear-armed states. However, contrary to the expectations of some, this is fueled less by the technological change brought about by AI than by the perception of threats and other's intentions in a world of ever-evolving military capabilities.

The Cult of Accelerated War

How U.S. and Chinese Warfighting Doctrines Increase the Risk of Escalation

Craig Neuman[1]

INTRODUCTION

In 2018, the Department of Defense released a new National Defense Strategy (NDS) and with it, a stark shift in the United States' national security priorities. Following nearly two decades of counterterrorism and counterinsurgency operations, the NDS proclaimed a return of great power competition and renewed focus on the threat of interstate conflict.[2] Senior defense officials routinely echo the strategy's warning of eroded U.S. dominance and regularly cite the immense growth in Chinese military power as their foremost example.[3]

As the People's Liberation Army (PLA) pursues wide-ranging reforms, its modernized equipment, emerging operating concepts, and increasingly professionalized forces are changing the balance of power in East Asia. In the event of conflict, the U.S. military will face an increasingly sophisticated "anti-access, area denial" system to challenge its traditional way of war across all warfighting domains (land, sea, air, space, and cyberspace). Robust air defense networks will threaten all but the most stealthy aircraft, while ballistic and cruise missiles will target regional airfields and naval formations with massed, precise fire. Counterspace and information warfare units will threaten U.S.

1. Lt Col Craig Neuman, PhD is an Air Force officer and special operations pilot with multiple overseas deployments. The views expressed are those of the author and do not reflect the official policy or position of the Department of the Air Force or the U.S. government.
2. Department of Defense, *Summary of the 2018 National Defense Strategy of the United States of America* (Washington D.C.: Department of Defense, 2018), https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.
3. Aaron Mehta, "In Testimony, Shanahan Underlines it's 'China, China, China,'" DefenseNews, March 14, 2019, https://www.defensenews.com/pentagon/2019/03/14/in-testimony-shanahan-underlines-its-china-china-china/.

command and control systems; GPS and communication networks; and intelligence, surveillance, and reconnaissance (ISR) platforms.[4]

As analysts contemplate this military balance, concerns over nuclear escalation have grown increasingly salient. As Thomas Schelling famously wrote, any crisis between two nuclear-armed powers is a nuclear crisis, where even low-level conventional action can escalate into nuclear conflict.[5] Among the various scenarios that could involve nuclear use, many of today's scholars focus on inadvertent escalation, where conventional military campaigns inadvertently threaten Chinese nuclear forces; intertwined command and control links; or conventional defensive systems that simultaneously protect China's nuclear deterrent. By threatening the survivability of their retaliatory arsenal, inadvertent escalation creates a "use it or use it" dilemma, where adversaries face a closing window of opportunity to use their weapons before they are possibly destroyed in a disarming first strike.[6]

Although U.S. and Chinese force postures increase the risk of inadvertent escalation, this paper argues that further escalation pressures exist independent of this "use it or lose it dilemma." Rather than raising adversary fears of preemptive strike, escalation pressures rest on the convergence of U.S. and Chinese visions of future war, notably the simultaneous drive for high-velocity, information-centric, and multi-domain campaigns. The interaction of these warfighting concepts and visions increases the risk of deliberate nuclear use by confronting Chinese leaders with a conflict that threatens to rapidly exceed their sense of control or acceptable limits. Faced with this circumstance, Chinese leaders may find a limited nuclear strike or demonstration a risky but tempting means to shock the United States into terminating a conflict that threatens to undermine core regime interests and security.

INADVERTENT ESCALATION: FROM THE COLD WAR TO TODAY

Since the beginning of the nuclear age, many authors have examined the political effects of nuclear weapons and the ways their destructive power would change the likelihood and conduct of war.[7] This destructive potential offered immense coercive and warfighting advantages, but also provided similarly armed adversaries the ability to exact unacceptable costs in retaliation. To insulate against these costs, strategists examined the feasibility and risks of preemptive attack and recognized how the vulnerability of either side's arsenal would drive pressures to escalate quickly in the opening stages of a conflict. Countries would be tempted to preempt their adversaries' vulnerable arsenals, while those adversaries would feel similar pressures to "use or lose" their weapons in the face of a possible disarming first strike.[8]

4. Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2019* (Washington D.C.: Department of Defense, 2019), https://media.defense.gov/ 2019/May/02/2002127082/-1/-1/1/2019_CHINA_MILITARY_POWER_REPORT.pdf; David Shambaugh, *Modernizing China's Military: Progress, Problems, and Prospects* (Oakland, CA: University of California Press, 2002); Robert Haddick, *Fire on the Water: China, America, and the Future of the Pacific* (Naval Institute Press, 2014); Stephen Biddle and Ivan Oelrich, "Future Warfare in the Western Pacific: Chinese Antiaccess/Area Denial, US AirSea battle, and Command of the Commons in East Asia." *International Security* 41, no. 1 (Summer 2016): 7-48.

5. Thomas Schelling, *Arms and Influence*, (New Haven, CT: Yale University Press, 1966), 1-34. See also: Matthew Kroenig, "Nuclear Superiority and the Balance of Resolve; Explaining Nuclear Crisis Outcomes." *International Organization* 67, no. 1 (January 2013): 141-171.

6. Caitlin Talmadge, "Would China Go Nuclear? Assessing the Risk of Chinese Nuclear Escalation in a Conventional War with the United States," *International Security* 41, no. 4 (Spring 2017): 50-92; James M. Acton, "Escalation Through Entanglement: How the Vulnerability of Command-and-Control Systems Raises the Risks of an Inadvertent Nuclear War," *International Security* 43, no. 1 (Summer 2018): 56-99; Keir A. Lieber and Daryl G. Press, *Coercive Nuclear Campaigns in the 21st Century: Understanding Adversary Incentives and Options for Nuclear Escalation* (Monterey, CA: Naval Postgraduate School, 2013).

7. Bernard Brodie, *Strategy in the Missile Age* (Monterey, CA: RAND, 1959); Robert Jervis, *The Illogic of American Nuclear Strategy* (Ithaca, NY: Cornell University Press, 1984); Lawrence Freeman, *The Evolution of Nuclear Strategy, Third Edition* (London: Palgrave Macmillan, 2003); Thomas Schelling, *The Strategy of Conflic*t (Cambridge, MA: Harvard University Press, 1960); Schelling, 1966.

8. Schelling, *Arms and Influence; Brodie, Strategy in the Missile Age.*

As survivable second-strike capabilities entered the U.S. and Soviet arsenals, concerns over first-strike stability gave way to arguments over the credibility of nuclear use in the face of assured retaliation. No policymaker could rationally order the launch of nuclear weapons knowing that it faced unacceptable punishment in return. While the balance of terror produced a measure of strategic stability, it also produced a search for pathways to nuclear use when nuclear use was never a rational choice. To answer this puzzle, Thomas Schelling argued that even in the presence of secure second-strike arsenals, there were risks of accidental, unforeseen, or unauthorized use of nuclear weapons in high-pressure crises. This risk would not only increase as crises grew in intensity, but could also be rationally manipulated for political advantage.[9] This "risk that leaves something to chance" could be an accidental or mistaken launch in the presence of fallible warning systems[10] or a deliberate launch by lower-level commanders facing the imminent overrun of their positions.

Alternatively, Barry Posen advanced a theory of "inadvertent escalation" in the final years of the Cold War. Posen argued that beyond traditional concerns over accidental or unauthorized launch, U.S. conventional military campaigns could threaten the survivability of Soviet nuclear weapons and revive earlier "use it or lose it" fears. Critically, these campaigns would threaten Soviet nuclear weapons as U.S. commanders pursued conventional objectives against conventional Soviet forces. For example, the United States could strike Soviet air defense systems to enable conventional operations but doing so would unintentionally open routes to attack Soviet nuclear weapons that relied on conventional air defenses for protection. Even though U.S. forces might not have intended a disarming first strike, these actions would inadvertently increase the temptation for preemptive targeting as Soviet forces grew more vulnerable, and it would similarly increase anxiety in Soviet leaders over the likelihood of these attacks.[11]

As Chinese military forces have grown in power and sophistication, scholars have recently applied the risks of inadvertent escalation to potential conflicts between the United States and a modernized China. One risk involves the accidental targeting of Chinese nuclear weapons as U.S. forces try to preempt ballistic missiles and the associated command and control networks that threaten its regional air bases.[12] As noted by Caitlin Talmadge, Chinese conventional and nuclear missile forces may be collocated at the same missile bases, use overlapping command and control arrangements, or field identical missiles in both nuclear and conventional configurations. This makes Chinese nuclear missiles a plausible, yet accidental, target during a conventional campaign to interdict conventional missiles that are the most pressing challenge to U.S. power projection forces. Similarly, strikes on Chinese submarines, even if restricted to conventional attack variants, can endanger the survivability of China's future sea-based deterrent by eliminating its primary means of defense.[13]

In the space domain, James Acton argues that the "entanglement" of missile warning, communication, and nuclear command and control satellites offers an additional risk of escalation during a conventional war.[14] To target Chinese ballistic and cruise missiles, Acton argues that the United States would heavily rely on missile warning and intelligence satellites to find, fix, and target many of these

9. Schelling, *Strategy of Conflict; Schelling, Arms and Influence.*
10. Bruce Blair, *The Logic of Accidental Nuclear War* (Washington DC: Brookings Institution, 1993).
11. Barry Posen, *Inadvertent Escalation* (Ithaca, NY: Cornell University Press, 1991).
12. Thomas Shugart and Javier Gonzalez, *First Strike: China's Missile Threat to U.S. Bases in Asia* (Washington, DC: Center for a New American Security, 2017), https://s3.amazonaws.com/files.cnas.org/documents/CNASReport-FirstStrike-Final.pdf?m-time=20170626140814.
13. Talmadge, "Would China Go Nuclear?"; Dennis Blair and Caitlin Talmadge, "Would China Go Nuclear?" *Foreign Affairs* 98, no 1 (January/February 2019), https://www.foreignaffairs.com/articles/china/2018-10-15/beijings-nuclear-option.
14. Acton, "Escalation Through Entanglement."

mobile systems. To protect their forces and gain a warfighting advantage, adversaries would likely destroy or disrupt U.S. satellite capabilities that enable this missile warning, in addition to other communications and ISR spacecraft.[15] Acton argues that the United States relies on many of these satellites for nuclear warning and command and control, so the destruction of these satellites would limit U.S. responsiveness and also contribute to escalatory pressures.

While today's scholarship focuses on inadvertently driving "use it or lose it" pressures, it neglects a different pathway of escalation that isn't mitigated by more precise targeting or is subject to debates over the ability for U.S. forces to discriminate between conventional and nuclear systems.[16] Instead, the interaction of U.S. and Chinese warfighting doctrines and capabilities risks rapid and comprehensive escalation during conflicts, possibly to the level of nuclear use.

These images of war prioritize rapid, high-technology attacks on enemy systems and strive to maximize their own access to information while simultaneously denying it to their enemy. In this vision, initiative reigns supreme, as inherently vulnerable space and network capabilities grow more vital for long-range strike, data transfer, and intelligence. These vulnerabilities maximize incentives to strike first or rapidly escalate a conflict, as both competitors seek to accelerate the pace of aggressive, offensive operations to paralyze adversary decision making.

These mutually agreeing and reinforcing images parallel a similar convergence prior to the First World War. Stephen Van Evera termed this phenomenon the "cult of the offensive," where European military and political leaders shared a belief in the inherent superiority of offense over defense. They believed the side to mobilize or attack first would have a substantial advantage and experienced strong pressures to preemptively mobilize or strike if they thought their opponents were preparing to attack. Ultimately, these shared beliefs and doctrines interacted in a way that exacerbated the political-military conditions at the time and ultimately unleashed an irresistible cycle of escalation.[17]

Today we see a similar convergence in U.S. and Chinese military doctrine and a belief in the power of speed, first strike, and information advantage. I argue that this convergence may increase Chinese incentives for deliberate nuclear use to halt or end a rapidly expanding conventional conflict. Specifically, a future conflict will quickly threaten to escalate out of control and will fuel uncertainty over adversary intentions, capabilities, or actions as each side operates in an information-degraded environment. In this circumstance, Chinese leaders may find nuclear use an attractive means of shocking the United States into conflict termination, particularly when battling over high-salience issues (like Taiwan) and when risking the rapid and comprehensive destruction of military forces that uphold the regime.

CONVERGING IMAGES OF WAR

As the U.S. and Chinese militaries prepare for conflict, each faces a technologically advanced adversary with complex and sophisticated capabilities in all warfighting domains. Each side is preparing to strike at great distances and is fielding robust ISR networks to allow long-range targeting against both fixed and mobile assets. Each side believes information will reign supreme,

15. Office of the Secretary of Defense, *Annual Report to Congress*, 49-51; Dean Cheng, Cyber Dragon: Inside China's Information Warfare and Cyber Operations (Santa Barbara, CA: Praeger, 2016).
16. Blair and Talmadge, "Would China Go Nuclear?" Many intelligence capabilities are highly classified, so debates over the quality of intelligence and discrimination of targeting capability will remain shrouded behind this classification barrier.
17. Stephen Van Evera, "The Cult of the Offensive and the Origins of the First World War," *International Security* 9, no. 1 (Summer 1984): 58-107.

and the side that can secure high-quality information of the battlespace and enemy forces (while denying the same to its adversary) will ultimately prevail.

The PLA describes its warfighting construct as "system destruction warfare," and seeks to "paralyze and even destroy the critical functions of an enemy's operational system."[18] It recognizes U.S. dependence on critical satellites, command and control aircraft, and digital networks and is explicitly developing systems to target these dependencies. In the air, this includes large, commercial airline-sized aircraft like the E-3 AWACS and E-8 JSTARS. Sophisticated Chinese air defenses like the S-300 and S-400 push these aircraft farther from the battlespace to limit the effectiveness of their organic radars, while long-range air-to-air missiles seek to attack these aircraft beyond the reach of U.S. defensive fighters.[19] To target U.S. satellites, the PLA is developing a robust suite of antisatellite missiles, terrestrial-based directed energy weapons, and co-orbital offensive satellites.[20]

In cyberspace, the PLA Strategic Support Force (PLASSF) was organized to fuse weapons and operations throughout the electromagnetic spectrum to target U.S. battle networks and paralyze and confuse U.S. forces.[21] The PLASSF aims to "sabotage the enemy's war command system of systems" and preemptively sabotage information, target enemy decisionmaking, and seize information control.[22] By taking the initiative and aggressively striking U.S. information systems at the outset of conflict, the PLA hopes to cause cascading failures in U.S. networks and exploit this advantage for rapid success.

The United States promotes a similar vision of future warfare that stresses the importance of information dominance for success. Resting on historic promises of network-centric warfare, the United States has historically sought to blind adversary radars and disintegrate command and control networks in the course of conflict.[23] Today, many military leaders discuss the advantages of decision speed to outmaneuver enemy forces and eliminate their ability to react or counter U.S. operations.[24] To do so, they hope to link together numerous sensors throughout the battlespace to produce vast quantities of information and leverage big data technologies and artificial intelligence to assist commanders in making rapid, high-quality decisions.[25]

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18. Jeffrey Engstrom, Systems Confrontation and Systems Destruction Warfare: How the Chinese People's Liberation Army Seeks to Wage Modern Warfare (Santa Monica, CA: RAND, 2018), https://www.rand.org/content/dam/rand/ pubs/research_reports/RR1700/RR1708/RAND_RR1708.pdf
19. Kyle Mizokami, "The U.S.'s New Missile Will Counter Chinese Fighters," Popular Mechanics, June 28, 2019, https://www.popularmechanics.com/military/weapons/a28210607/aim-260-missile/. The author cites open-source estimates that the Chinese PL-15's maximum range is beyond the United States' comparable air-to-air missile, the AMRAAM.
20. National Air and Space Intelligence Center, Competing in Space (Wright-Patterson AFB, OH: National Air and Space Intelligence Center, 2018), https://media.defense.gov/ 2019/Jan/16/2002080386/-1/-1/1/190115-F-NV711-0002.PDF; Defense Intelligence Agency, Challenges to Security in Space (Washington, DC: Defense Intelligence Agency, 2019), https://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/Space_Threat_V14_020119_sm.pdf.
21. Cheng, Cyber Dragon, 93.
22. John Costello and Joe McReynolds, China's Strategic Support Force: A Force for a New Era (Washington, DC: National Defense University Press, 2018), http://inss.ndu.edu/Media/News/Article/1651882/chinas-strategic-support-force-a-force-for-a-new-era/; Elsa B. Kania and John Costello, "The Strategic Support Force and the Future of Chinese Information Operations," The Cyber Defense Review (Spring 2018): 105-121, https://cyberdefensereview.army.mil/Portals/6/Documents/CDR%20Journal%20Articles/The%20Strategic%20Support%20Force_Kania_Costello.pdf?ver=2018-07-31-093713-580; Byran Krekel, Patton Adams, and George Bakos "Occupying the Information High Ground: Chinses Capabilities for Computer Network Operations and Cyber Espionage," International Journal of Computer Research 21, no. 4 (2014): 333-439.
23. Lieber and Press, "Coercive Nuclear Campaigns," 36.
24. Jim Garamone, "Dunford: Speed of Military Decision-Making Must Exceed Speed of War," DoD News, January 31, 2017, https://www.jcs.mil/Media/News/News-Display/Article/1067479/dunford-speed-of-military-decision-making-must-exceed-speed-of-war/.
25. General David Goldfein, "Enhancing Multi-Domain Command and Control…Tying It All Together," U.S. Air Force, https://www.af.mil/Portals/1/documents/csaf/letter3/Enhancing_Multi-domain_CommandControl.pdf.

New programs like the Advanced Battle Management System are one element of this vision of networked sensors and shooters, and U.S. Air Force leaders urge lawmakers (and the public) to look at the capabilities of interconnected systems rather than individual platforms.[26] Above all, these systems are designed to generate rapid effects to maintain the initiative and generate "multiple, simultaneous dilemmas" faster than adversary decisionmaking processes can respond. Like their Chinese opponents, it is hard to overestimate the importance of information and speed to these U.S. warfighting constructs.[27]

EXACERBATING THE RISKS OF ESCALATION

These converging warfighting doctrines and images increase the risks of escalation in several ways, primarily through the speed and scope of vertical and horizontal escalation and the effects of information operations.

Speed and Scope of Vertical Escalation. The two most-cited potential conflicts between the United States and China (Taiwan and the South China Sea) involve warfighting domains that prize preemption and aggressive initiative: air, space, and cyber. A primary tenant of airpower is that it is much easier to destroy an opponent's air force on the ground than battle individual aircraft in the air. Recent RAND wargames illustrate the power of preemptive attacks on U.S. air bases in the region and routinely describe the devastating loss of aircraft to Chinese long-range missile forces.[28]

Space is also described as an offensive-dominant domain with first-strike incentives.[29] In space, satellites travel in relatively predictable orbits, are difficult to hide, carry a fixed amount of fuel for maneuvering, and operate in a hostile environment where even minor debris can cause critical failures. Furthermore, the cost-exchange ratio between satellites and antisatellite (ASAT) weapons also favors the attacker, where the cost to launch a payload into orbit is a direct function of its weight. Kinetic energy ASAT interceptors will likely weigh much less than the satellites they target and be cheaper than the sophisticated sensors and equipment attached to these targets.[30] Beyond kinetic ASATs, space systems are also vulnerable to a wide range of other attack vectors, from electromagnetic jamming, cyberattacks on ground infrastructure, directed energy to blind or disable satellite sensors, and many others.[31] To exploit these first-strike advantages and preemptive dynamics, Chinese strategists emphasize "rapid, decisive action" in space and that attaining space control will have the greatest effect on achieving information dominance, a central component of future conflict.[32]

Despite the debate over the offense-defense balance in cyberspace,[33] most scholars and practitioners argue that the nature of cyberspace and network technology provides intruders the advantage[34] and

26. U.S. Senate Armed Services Committee, Hearing to Receive Testimony on the Posture of the Department of the Air Force in Review of the Defense Authorization Request for Fiscal Year 2020 and the Future Years Defense Program, 116th Cong, 1st sess., April 4, 2019, https://www.armed-services.senate.gov/imo/media/doc/19-34_04-04-19.pdf.
27. Mark Pomerleau, "How Information Advantage Will Help Win Future Conflicts," C4ISRNET, June 12, 2018, https://www.c4isrnet.com/c2-comms/2018/06/12/how-information-advantage-will-help-win-future-conflicts/.
28. Sydney J. Freedberg Jr, "U.S. 'Gets Its Ass Handed to It' in Wargames: Here's a $24 Billion Fix," Breaking Defense, March 7, 2019, https://breakingdefense.com/2019/03/us-gets-its-ass-handed-to-it-in-wargames-heres-a-24-billion-fix/.
29. Forrest E. Morgan, Deterrence and First-Strike Stability in Space: A Preliminary Assessment (Santa Monica, CA: RAND, 2010), https://www.rand.org/content/dam/rand/pubs/monographs/2010/RAND_MG916.pdf.
30. Biddle and Oelrich, "Future Warfare in the Western Pacific."
31. National Air and Space Intelligence Center, "Competing in Space."
32. Cheng, Cyber Dragon, 155-176.
33. Rebecca Slayton, "What is the Cyber Offense-Defense Balance? Conceptions, Causes, and Assessment." International Security 41, no. 3 (2017): 72-109; Keir Lieber, "The Offense-Defense Balance and Cyber Warfare." Cyber Analogies (2014): 96-107.
34. Ben Buchanan, The Cybersecurity Dilemma: Hacking, Trust, and Fear Between Nations (New York: Oxford University Press,

that no system can be perfectly immune to compromise.[35] However, it takes significant time, money, and effort to create exploits for use on sophisticated adversaries.[36] If peacetime vulnerabilities may be closed during conflict, either through last-minute software patches or reconfigured network topology, attackers have an incentive to rapidly use exploits before the opportunity disappears.[37] Similarly, if these exploits only offer temporary advantages (either through adversary countermeasures or defensive efforts to expel intruders), attackers must move swiftly to leverage these openings.[38]

While each domain prioritizes preemptive strikes or rapid operations to exploit successes, the combination and interaction of these domains can exacerbate their individual first-strike tendencies. For example, if U.S. air bases are vulnerable to mobile missile attacks, the United States may rely on satellite observation for locating these missiles and preemptive air or cyber strikes to negate their threat. Knowing the U.S. reliance on satellites to track these missiles, Chinese forces would seek to rapidly destroy U.S. satellites to protect their ability to preemptively attack U.S. bases with barraged missile fire. The "entanglement" of domains and intertwined dependence of these forces can lead to rapid, cross-domain escalation in an attempt to secure advantage.

Critically, this early and rapid escalation sequence negates one of the primary methods for controlling escalation in war. In his seminal study of intrawar escalation, Richard Smoke studied seven conventional conflicts for lessons on limiting conflict. His three successful cases of limited escalation all involved "an initial period of stability" that "lasted long enough for expectations to develop among policy-makers … that the war might well remain a reasonably controlled one."[39] Even though some limits were crossed later in the conflict, Smoke shows that successful cases of escalation control require early periods of stability or restraint. Warfighting doctrines that emphasize offensive or preemptive action and seek to exploit early or fleeting opportunities eliminate these early periods and will likely create expectations of *unlimited* conflict.

Furthermore, escalation control requires operational pauses to "encourage mutual restraint and to afford diplomatic efforts greater opportunity to prevail and succeed."[40] Unfortunately, the United States and China are preparing for a race in military decision and execution cycles. U.S. military leaders routinely invoke the Observe-Orient-Decide-Act (OODA) loop model of action and believe that victory accrues to the actor who can execute the faster cycle.[41] Chinese writers similarly invoke OODA-loop concepts and describe information attacks to slow, degrade, or destroy each element of

2016); David E Sanger, The Perfect Weapon: War, Sabotage, and Fear in the Cyber Age (New York: Broadway Books, 2019): 2.
35. John P. Carlin and Garrett M. Graff, Dawn of the Code War: America's Battle Against Russia, China, and the Rising Global Cyber Threat (New York: Public Affairs, 2018).
36. Cheng, Cyber Dragon, 139; Sanger, The Perfect Weapon, 45; Buchanan, Cybersecurity Dilemma, 36.
37. Cheng Cyber Dragon, 139; Amy Zegart and Michael Morell, "Spies, Lies, and Algorithms: Why U.S. Intelligence Agencies Must Adapt or Fail," Foreign Affairs 98, no. 3 (May/June 2019), https://www.foreignaffairs.com/articles/ 2019-04-16/spies-lies-and-algorithms.
38. David C. Gompert and Martin Libicki, "Cyber Warfare and Sino-American Crisis Instability," Survival 56, no. 4 (2014): 7-22.
39. Richard Smoke, War: Controlling Escalation (Cambridge, MA: Harvard University Press, 1977), 296. His three cases of successful escalation control were the Austro-Prussian War, the Franco-Prussian War, and the Spanish Civil War.
40. Gordon Craig and Alexander George, quoted in Kerry M. Kartchner and Michael S. Gerson, "Escalation to Limited Nuclear War in the 21st Century," in On Limited Nuclear War in the 21st Century, eds. Jeffrey A. Larsen and Kerry M. Kartchner (Stanford: Stanford University Press, 2019), 161.
41. The OODA loop originally came from John Boyd, a U.S. Air Force fighter pilot and instructor at the Air Force Fighter Weapons School, who began briefing Pentagon leaders on his theories in the early 1980s. Robert Coram, Boyd: The Fighter Pilot Who Changed the Art of War (New York: Back Bay Books, 2004). For an example of the enduring impact of the OODA loop, see General David Goldfein, "Keynote Address," (presented at the Air Force Association Air Warfare Symposium, Orlando, Florida, February 23, 2018), https://www.af.mil/Portals/1/documents/csaf/CSAF_AFA_Orlando-23Feb18.PDF.

the cycle.[42] Operational pauses are to be avoided at all costs because slowing the pace of warfare cedes the initiative to the enemy and becomes the essence of defeat in an information-centric contest of OODA-loops.[43]

Speed and Scope of Horizontal Escalation. One time-honored means of controlling escalation is to establish boundaries on where conflict occurs.[44] These commitments can be either explicit or tacit but restricting military operations to clearly defined geographic limits can help reinforce mutual expectations on the limited nature of the conflict. Though some geographically restricted conflicts can still escalate to unacceptable levels, restricting the geographic scope of military operations can provide some means of reassuring adversaries of limited intent. Indeed, this may only be a meaningful signal when adversaries experience some natural pressure to widen the scope of a conflict into otherwise conflict-free areas.

Air, space, and cyber capabilities involved in a U.S.-China conflict will be global in scope. Indeed, numerous studies on future threat environments cite the need for greater long-range strike platforms to ease U.S. dependence on close-in and vulnerable air bases and ships.[45] Because these systems will originate far from any localized conflict, efforts to counter or preemptively destroy them will require attacks deep in adversary or allied homelands. For the United States, bombers may execute combat operations from bases within the United States, while space and cyber warriors may generate attacks, launch replacement satellites, or rely on tracking and warning radar sites within the United States or worldwide. To target ships at sea, satellites in orbit, or U.S. bombers far from the mainland, China will also rely on air bases, radars, missiles, and lasers throughout the Chinese mainland.[46]

Rather than confining military operations to local actors exacting local damage, future warfighting concepts will rely on globally dispersed forces and increased pressure for equally expansive targeting. Indeed, the U.S. National Defense Strategy directs efforts to "expand the competitive space," a phrase synonymous with horizontal escalation.[47] Likely built on the military dictum to attack an adversary's weaknesses rather than strengths, U.S. efforts to "expand the competitive space" will involve more than preempting the direct military forces China uses in a Taiwan or South China Sea conflict. Instead, it could involve operations that target peripheral Chinese interests or capabilities and explicitly widen the nature of the conflict to exact additional costs on Chinese decisionmakers.

Effects and Contingency Plans for Information-Centric Warfare. Future U.S. and Chinese operating concepts both stress the centrality of information dominance. Defined as "the operational advantage gained from the ability to collect, control, exploit, and defend information to optimize decision making and maximize warfighting effects," both sides will seek to disable, destroy, or deceive their opponent's

42. Cheng, Cyber Dragon, 89, 108.
43. The claim that military forces have offensive preferences isn't new (for example, Scott Sagan's work in Scott D. Sagan and Kenneth Waltz, The Spread of Nuclear Weapons: An Enduring Debate [New York: W.W. Norton & Company, 2012]), but modern war makes the speed of operations and continued pressure to stay inside the adversary's OODA loop a new urgency. This is the result of traditional military proclivities for the offense combined with new technology and RMA-style precepts.
44. Andrew L. Ross, "The Origins of Limited Nuclear War Theory." in On Limited Nuclear War in the 21st Century, eds. Jeffrey A. Larsen and Kerry M. Kartchner (Stanford: Stanford University Press, 2019), 22-48.
45. Mark Gunzinger, Carl Rehberg, Jacob Cohn, Timothy A. Walton, and Lukas Autenried, An Air Force for an Era of Great Power Competition (Washington, DC: Center for Strategic and Budgetary Assessments, 2019).
46. Eric Heginbotham et al., The U.S.-China Military Scorecard: Forces, Geography, and the Evolving Balance of Power 1996-2017 (Santa Monica, CA: RAND, 2017), https://www.rand.org/pubs/research_reports/RR392.html.
47. United States Institute of Peace, Providing for the Common Defense: The Assessment and Recommendations of the National Defense Strategy Commission (Washington DC: United States Institute of Peace, 2019), 19-20, https://www.usip.org/sites/default /files/2018-11/providing-for-the-common-defense.pdf.

understanding of the battlespace.[48] Whether through direct attacks on enemy sensors or the networks that transmit this information, each side intends to target the breadth of enemy command and decisionmaking systems to induce paralysis or force their opponents to make mistakes and create opportunities to exploit. The target is not simply the links that connect commanders with their forces in the field (or to coordinate between those forces), but the ability of these commanders to gather quality information in the first place. This drive to isolate or confuse opponents' understanding of the conflict can undermine any sense of mutual agreement on the limits of the conflict.

Deliberately polluting an adversary's sense of control may be a potent mechanism for defeating conventional fighting formations, but it is dangerous in a nuclear context. Adversaries resist the temptation to escalate not only by a shared sense of limits, but also a shared sense of control in preserving those limits. In a peer-conflict, battles over information will likely involve the degradation of *both* sides' information systems. Reciprocal uncertainty over the status of enemy (or friendly) forces can induce fear of the overall trajectory of the conflict and produce strong pressures to terminate the conflict in the shortest possible time. In this context, doubts over the quality of information can also inhibit the receipt, understanding, or trust of adversary signals for tacit bargaining and increase demands for "loud," obvious signals to shock opponents into restraint.

Furthermore, U.S. forces are striving to incentivize greater lower-level initiative in the face of disrupted command and control networks. To cope with degraded communication and data flow, the U.S. military is pushing the concept of "mission command."[49] This concept ensures that lower-level leaders can design operations to meet their commander's overall intent, and execute these activities *independent of explicit direction by their commander*. Unfortunately, escalation control in the midst of a severe crisis requires careful coordination of diplomatic and military activity.[50] To calibrate signals to their adversaries, senior leaders and decisionmakers must deliberately modulate the character and intensity of military force to align with high-level negotiations or crisis communication.

In fact, the power to restrain this force or dynamically set new limits may be the most demanding—and important—aspect of escalation control during wartime.[51] Needless to say, offensively-minded units exercising independent initiative (based on their last understanding of "commander's intent") can challenge a central authority's ability to modulate the use of force and de-escalate a crisis.[52] For example, if U.S. policymakers commit to a particular limit but are unable to communicate with the forces that must abide by this limit, continued attacks from those forces could be misperceived by the Chinese as U.S. duplicity.

Finally, a lack of trustworthy information or sense of control will radically diverge from Chinese expectations of war. The Western military tradition recognizes the inevitable fog and friction of war and the need to improvise in the face of unexpected challenges.[53] Alternatively, Chinese military culture views war as a science and an almost mechanistic process. Chinese military writing assumes a

48. U.S. Air Force, Air Force Information Dominance Flight Plan (U.S. Air Force, 2017), https://www.safcioa6.af.mil/Portals/64/documents/20170203-%20IDFPv3.pdf?ver=2017-02-16-072244-507.
49. James D. Sharpe, Jr. and Thomas E. Creviston, "Understanding Mission Command," U.S. Army, July 10, 2013, https://www.army.mil/article/106872/understanding_mission_command.
50. Kartchner and Gerson "Escalation to Limited Nuclear War," 161.
51. Thomas Schelling mentions how coercive pressure also requires the guarantee that pain will stop if an adversary complies with your demands. Schelling, Arms and Influence.
52. Herman Kahn reminds us that "de-escalation is even more sensitive to accurate communication and shared understandings than escalation is." Herman Kahn, On Escalation: Metaphors and Scenarios (New York: Routledge, 2017): 231.
53. For example, Clausewitz is famous for introducing the term "fog and friction" in his timeless work. Carl von Clausewitz, On War, eds. Michael Howard and Peter Paret (Princeton: Princeton University Press, 1984).

high degree of control by military commanders and a significant ability to shape and influence events to desired outcomes.[54] A breakdown of this image of control can intensify many of the cognitive difficulties and conceptual failures leaders experience during crisis or war.[55]

NO FIRST USE AND ACCELERATED WAR

This paper argues that rapid escalation in future warfare may incentivize the deliberate first use of nuclear weapons, albeit as a limited strike or demonstration. Critically, China has long maintained a No First Use (NFU) policy that appears to rule out this very outcome. However, the credibility of a NFU pledge in these circumstances is probably low, while current Chinese force structure and ambiguity over the limits of this policy make this type of strike more plausible than a NFU policy would appear.

First, China's NFU is not absolute and maintains some ambiguity to complicate adversary decisionmaking. Specifically, many scholars believe this ambiguity is designed to deter conventional attacks against Chinese nuclear forces.[56] Ultimately, Chinese nuclear forces (and conventional forces for that matter) exist to preserve the security and existence of the regime. If there are exceptions to NFU to preserve the ultimate tools of regime safety, it's logical that exceptions would also be made during severe threats to the regime even when those threats aren't directed at its nuclear deterrent.

Second, China's nuclear arsenal contains a large number of medium- and intermediate-range missiles that would be ideal candidates for limited strikes and are physically incapable of threatening the U.S. homeland. Indeed, the choice of a missile that cannot reach the U.S. homeland could serve a signaling purpose on its own. For example, the DF-21 and DF-26 are both road-mobile, nuclear-capable missiles but cannot reach much farther than the second island chain.[57] These weapons may be hard to fit in assured retaliation postures that prioritize countervalue targeting, but Chinese publications are clear that their nuclear doctrine still targets military forces, though not as a true counterforce campaign.[58] These targets would involve attacks on military bases or command and control centers rather than ICBM silos or other damage-limitation targets.[59]

To meet their goals, Chinese nuclear targeting aims "primarily to shock an adversary into submission in the hopes of de-escalating a conflict."[60] Rather than selecting targets for instrumental warfighting advantage, Chinese strategy aims to produce unacceptable losses that shake the enemy's will to fight and deter further escalation. [61] A demonstration or limited strike would serve a similar psychological purpose and align with this bedrock principle of Chinese nuclear operations. Even if this was not their designed intent, the further development of these

54. Thomas Mahnken, Secrecy and Stratagem: Understanding Chinese Strategic Culture (Double Bay, Australia: Lowry Institute for International Policy, 2011), https://archive.lowyinstitute.org/sites/default/files/pubfiles/Mahnken%2C_Secrecy_and_stratagem_1.pdf; Alison A. Kaufman and Daniel M. Hartnett, Managing Conflict: Examining Recent PLA Writings on Escalation Control (Arlington, VA: CNA, 2016), https://www.cna.org/cna_files/pdf/DRM-2015-U-009963-Final3.pdf.
55. Smoke, War, 260-64.
56. Fiona S. Cunningham and M. Taylor Fravel, "Assuring Assured Retaliation: China's Nuclear Posture and U.S.-China Strategic Stability," International Security 40, no. 2 (Fall 2015): 7-50. M. Taylor Fravel and Evan S. Medeiros, "China's Search for Assured Retaliation: The Evolution of Chinese Nuclear Strategy and Force Structure," International Security 35, no. 2 (Fall 2010): 48-87; Thomas J. Christensen, "The Meaning of the Nuclear Evolution: China's Strategic Modernization and US-China Security Relations." Journal of Strategic Studies 35, no. 4 (2012): 447-487.
57. Hans M. Kristensen and Robert S. Norris "Chinese Nuclear Forces, 2018." Bulletin of the Atomic Scientists 74, no. 4 (2018): 289-295.
58. Fravel and Medeiros, "China's Search for Assured Retaliation," 70.
59. Eric Heginbotham et al. China's Evolving Nuclear Deterrent: Main Drivers and Issues for the United States (Santa Monica, CA: RAND, 2017): 32, https://www.rand.org/pubs/research_reports/RR1628.html.
60. Fravel and Medeiros, "China's Search for Assured Retaliation," 77.
61. Heginbotham et al., China's Evolving Nuclear Deterrent, 33.

classes of weapons may open options for limited nuclear use that did not exist before and may be tempting in the heat of conflict.

Finally, the geography of potential conflict points could allow a limited strike or demonstration with little danger of collateral damage or fallout overpopulated areas. For example, threats from Chinese conventional missiles will push U.S. naval vessels far from the mainland coast. An attack on these ships would be "discriminant" according to the laws of war,[62] and winds could carry the fallout of a detonation over the open ocean, depending on their prevailing direction.

In summary, this paper introduced a new dimension on how conventional military operations can impact nuclear escalation. Rather than focus on inadvertent threats to nuclear forces, it argues that converging U.S. and Chinese images of future warfare produce strong escalatory pressures. Many of the applicable warfighting domains are global in scope and prize preemption, their mutual dependencies exacerbate their first-strike advantages, and these warfighting approaches focus on paralyzing the adversary through unmatched speed and information attacks.

For leaders concerned about the risks of uncontrollable escalation, it is hard to find a better example than the fear of falling behind in an accelerating race of action and decision cycles. Indeed, the side that struggles to keep up, particularly when this race pollutes their understanding of the battlespace and their adversary's intentions, will reasonably feel that they are losing control over the war. When the stakes are high enough, a limited nuclear strike or demonstration becomes a dreadful, yet conceivable choice.

62. Office of General Counsel, Department of Defense Law of War Manual (Washington, DC: U.S. Department of Defense, 2015): 207, https://dod.defense.gov/Portals/1/Documents/pubs/DoD%20Law%20of%20War%20Manual%20-%20June%202015%20Updated%20Dec%202016.pdf?ver=2016-12-13-172036-190.

India's Sea-Based Deterrent

Evaluating the Effectiveness of India's Submarine Nuclear Deterrent

Dev Patel[1]

ABSTRACT

On November 5, 2018, India's Prime Minister Narendra Modi celebrated the first deterrent patrol of the INS Arihant, a nuclear-powered, ballistic missile-carrying submarine (SSBN), equipped with nuclear-tipped submarine-launched ballistic missiles (SLBMs). The successful month-long deterrent patrol of the Arihant marks the establishment of India's nuclear triad. This paper studies the extent to which India relies on its SSBN fleet to provide nuclear deterrence and to enhance second-strike capability.

INTRODUCTION

On November 5, 2018, Prime Minister Narendra Modi declared, "Today is historic because it marks the completion of the successful establishment of the nuclear triad. India's nuclear triad will be an important pillar of global peace and stability."[2] Modi's remarks followed the milestone achievement of the INS Arihant's first month-long deterrent patrol. The INS Arihant is a nuclear-powered, ballistic missile-carrying submarine (SSBN) that is armed with nuclear-tipped submarine-launched ballistic missiles (SLBMs). Currently, India is one of seven nations deploying nuclear weapons at sea. France, China, Russia, the United Kingdom, and the United States are also deploying SSBNs with North Korea attempting to develop the capability.[3] SSBNs offer the most reliable and survivable means of nuclear deterrence. Additionally, India continues to adhere to its long declared "No First Use" policy and "self-defensive nuclear strategy." As a result, the

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2. The Times of India, "Arihant Successfully Completes Its First Deterrence Patrol," *Times of India*, November 5, 2018, https://timesofindia.indiatimes.com/india/ins-arihant-successfully-completes-its-first-deterrence-patrol/articleshow/66510054.cms.
3. Dimitrios Mitsopoulos, "All the Nuclear Missile Submarines in the World in One Chart," *Popular Mechanics*, June 25, 2018, https://www.popularmechanics.com/military/navy-ships/a21204892/nuclear-missile-submarines-chart/.

SSBN fleet plays a central role in India's military strategy to retaliate in the event of an attack on the Indian homeland.[4]

THE ROLE OF THE SSBN IN THE NUCLEAR TRIAD

During the Cold War, the nuclear triad developed out of the arms race between the United States and the Soviet Union. The United States' Department of Defense website states that "Deterrence is a strategy that seeks to prevent an actor from taking specific action, and has been central to keeping peace for nearly 70 years" for the United States and its allies.[5] Throughout the Cold War, the historical conflict between India and Pakistan pushed both nations to develop nuclear weapons and an eventual triad. In addition, neighboring China has also developed a nuclear triad, which threatens India's national security. Prime Minister Modi has affirmed his support of developing nuclear weapons by stating that "Amid an increase in the number of nuclear weapons in our surroundings [Pakistan and China], a credible nuclear deterrence is extremely important for our country's security."[6]

In a nuclear triad, SSBNs comprise the sea leg and are essential for deterrence.[7] India, technically, employs a nuclear triad, which is a three-pronged military force structure that consists of SLBMs, land-based ballistic missiles, and strategic bombers. The three legs of the nuclear triad significantly reduce the probability that an aggressor nation could destroy all of a home nation's nuclear forces in a first-strike attack. Thus, the arsenal is designed to retain a second-strike capability, survive devastating losses incurred during a nuclear attack, and retaliate with a second strike.

ADVANTAGES

An SSBN fleet is vital to nuclear deterrence and national security.[8] These submarines act as a credible strategic nuclear deterrent for India due to their nuclear payload of their SLBMs, but also because these ships provide second-strike capability. Their missiles are launched vertically, strike over long-ranges, and are armed with multiple nuclear warheads. Nations with more established SSBN fleets, such as the United States, have multiple deployed SSBNs on patrol that are nearly undetectable and armed with missiles that can threaten and strike enemy targets worldwide.[9] Currently, India has only one in-service SSBN, the Arihant, which cannot be on station at all times due to maintenance, training, etc. Also, India's limited choice of missiles to arm the Arihant will enable it to hit coastal targets within ranges of 250 to 750 km.[10] These missile ranges will only slightly act as a deterrent to Pakistan, as the Arihant would have to launch missiles dangerously close and will only threaten the largest city of Karachi.

4. Kumar Sundaram et al., "India and the Policy of No First Use of Nuclear Weapons," *Journal for Peace and Nuclear Disarmament* 1, no. 1 (February 22, 2018): 152-68, https://doi.org/10.1080/25751654.2018.1438737.
5. "Special Report: 21st Century Nuclear Deterrence and Missile Defense," U.S. Department of Defense, https://dod.defense.gov/News/Special-Reports/21st-Century-Nuclear-Deterrence-and-Missile-Defense/.
6. Krishna N. Das, "India says nuclear submarine makes first patrol, Modi warns against 'misadventure'," Reuters, November 5, 2018, https://af.reuters.com/article/worldNews/idUSKCN1NA1HK.
7. Anna Schumann, "Fact Sheet: The Nuclear Triad," Center for Arms Control and Non-Proliferation, July 28, 2017, https://armscontrolcenter.org/factsheet-the-nuclear-triad/.
8. Kingston Reif, Travis Sharp, and Usha Sahay, "Pruning the Nuclear Triad?" Center for Arms Control and Non-Proliferation, May 16, 2013, https://armscontrolcenter.org/pruning-the-nuclear-triad-pros-and-cons-of-submarines-bombers-and-missiles/.
9. Richard W. Mies, "The SSBN in National Security," *Undersea Warfare Magazine* 2, no. 1 (Fall 1999), https://www.public.navy.mil/subfor/underseawarfaremagazine/Issues/Archives/issue_05/ntlsecurity.html.
10. Kelsey Davenport, "India," Arms Control Association, https://www.armscontrol.org/taxonomy/term/13.

CHALLENGES

There are several challenges for India in employing an effective sea-based nuclear deterrent.[11] First, Indian SSBNs must have operational stealth capability, as they must be hard to locate and tracked by adversaries in the ocean. Second, India must have a nuclear payload of SLBMs that are reliable and capable of hitting targets at intercontinental ranges. Lastly, India must also have a command and control structure that is survivable after an initial strike and able to reliably communicate with an SSBN in order for India to retaliate after being attacked.

EFFECTIVENESS

Indian strategist Bharat Karnad stated "the triad becomes effective when you have a submarine operational at all times."[12] India only has one commissioned SSBN, the Arihant, which logistically cannot operate (i.e., provide strategic deterrence) all the time due to training, maintenance, etc. If an adversary were to develop a way to locate the SSBN when deployed, a disarming first strike might disable the only SSBN they have. If India were able to eventually deploy multiple SSBNs at once, an attack on an SSBN force would make it more difficult to successfully destroy the whole fleet. According to the U.S. Navy Institute, "A continuous patrol requires a minimum of four SSBNs" and it points to the United States, Russia, France and the United Kingdom as nations possessing effective triads.[13] At any given time, the nations listed can continuously operate deterrent patrols at seas with at least one SSBN on station that can launch a nuclear warhead. This four SSBN deployment strategy assumes that the first submarine is on patrol for two to three months, the second SSBN is operating on standby, and the third and fourth SSBNs are at the homeport undergoing maintenance. Thus, India will need to go from one to four SSBNs to provide effective sea-based nuclear deterrence.

THE ADVANCED TECHNOLOGY VESSEL (ATV) PROJECT

During the India-Pakistan War of 1971, Russia dispatched ships and nuclear submarines from its Pacific Fleet in Vladivostok to counter a possible naval attack on Mumbai from the U.S.-British fleet.[14] Prime Minister Indira Gandhi was inspired to field an Indian nuclear submarine due to the Russian fleet's presence, which altered the course of the war. Thus, in 1974, India started Project 932 to build a nuclear-powered attack (SSN) submarine that would be fast, dive deep, and hunt surface ships.[15] The submarine program under the Department of Atomic Energy (DAE) culminated in an unviable nuclear reactor design in 1975, after spending about U.S. $15 million. By the mid-1980s, the DAE spent as much as U.S. $350 million in research and development and eventually failed due to bureaucracy and production woes.

The project was re-launched in 1985 under the Defense Research & Development Organization (DRDO) with the codename Advanced Technology Vessel (ATV). This time around, the Soviet Union heavily assisted India in producing an indigenous SSBN and SLBMs with many scientists and engineers being

11. China Power Team, "Does China have an effective sea-based nuclear deterrent?" China Power, December 28, 2015, updated May 2, 2019, https://chinapower.csis.org/ssbn/.
12. Sandeep Unnithan, " A Peek into India's Top Secret and Costliest Defence Project, Nuclear Submarines," *India Today*, December, 10, 2017, https://www.indiatoday.in/magazine/the-big-story/story/20171218-india-ballistic-missile-submarine-k-6-submarine-launched-drdo-1102085-2017-12-10.
13. Tim Fish, "First Nuclear Deterrence Patrol Marks Major Step for Indian Submarine Force," US Naval Institute News, November 12, 2018, https://news.usni.org/2018/11/12/first-nuclear-deterrence-patrol-marks-major-step-indian-submarine-force.
14. Rakesh K. Simha, "Arihant: How Russia helped deliver India's baby boomer," *Russia Beyond*, October 15, 2015, https://www.rbth.com/blogs/stranger_than_fiction/2015/10/26/arihant-how-rusia-helped-deliver-indias-baby-boomer_533849.
15. Arun K. Singh, "SSBMs-SLBMs: India's Necessity," *Defense and Security Alert* 10, no. 3 (2018): 6-9.

sent to India to help with production.[16] In 1988, the Soviet Union leased a Charlie-class SSN, the INS Chakra, to India for three years.[17] In 1998, India bought Soviet reactor designs and started construction of the Arihant's submarine hull. In July 2009, India launched the SSBN during a ceremony at Visakhapatnam on India's eastern coast. Russian assistance in the project was visible by the attendance of 143 Russian engineers, designers, and consultants. This knowledge-sharing relationship with Russia has continued to this day, as India continues to need help designing its reactor and propulsion plant. India and Russia have been allies for several decades, as India has bought about 70 percent of its military hardware and has heavily relied on nuclear expertise from Russia.[18]

Originally, the ATV program for building four SSBNs cost an estimated U.S. $13 billion, which made it India's largest defense program.[19] About 60 percent of the submarine components were built within India with collaboration from the Bhabha Atomic Research Center (BARC) for nuclear reactor development, the DRDO for SLBM development, and Russia for extensive design and technical assistance. Today, the ATV program has increased by an estimated U.S. $8.7 billion to accommodate for the construction of six nuclear-powered attack submarines, which would be equipped with torpedoes and conventional cruise missiles.

REACTOR DEVELOPMENT

Prior to the Arihant, BARC built a reactor prototype within a mock-up submarine hull at Kalpakkam, which became operational in 2006 and is still in use today to train military operators. [20] The Soviet Union originally provided India with the VM-5 190 MW reactor design and the technological expertise to scale it down to fit into the Arihant's hull.[21] After three years of operation, the prototype yielded data that helped refine, design, and develop the Arihant's 85 MW nuclear reactor, which uses 40 percent highly-enriched uranium (HEU) fuel.[22]

INDIA'S SSBN FLEET

India's SSBN fleet has been slow to develop and only recently has been a strategic and security priority for India. Table 1 compares the specifications of Indian SSBNs present and planned to those of other nations. The Arihant-Class still does not match up in almost every category. Thus, India has revealed plans and funding for more advanced SSBNs, known as the S5-class, but these ships are still in the early stages of design.

16. Ibid.
17. Simha, "Arihant: How Russia helped deliver India's baby boomer."
18. BBC News, "Russian-built nuclear submarine joins Indian navy," BBC News, April 4, 2012, https://www.bbc.com/news/world-asia-india-17606829.
19. Unnithan, "A Peek into India's Top Secret."
20. G.C. Shekhar, "Unveiled: Arihant's elder brother," *Telegraph*, March 8, 2009, https://www.telegraphindia.com/india/unveiled-arihant-s-elder-brother/cid/600230.
21. Praful Bidwai, "Sinking billions into nuclear weapons," Rediff.com, August 3, 2009, http://news.rediff.com/column/2009/aug/03/sinking-billions-into-nuclear-weapons.htm.
22. George M. Moore, Cervando A. Banuelos, and Thomas T. Gray, *Replacing Highly Enriched Uranium in Naval Reactors* (Monterey, CA: Nuclear Threat Initiative, 2016), https://media.nti.org/pdfs/Replacing_HEU_in_Naval_Reactors_Report_FINAL.pdf.

Table 1: Comparison of SSBNs between India and Other Nations.[23,24,25,26,27,28]

COUNTRY	INDIA	U.S.	CHINA	FRANCE	UK	RUSSIA
Class	Arihant/S5	Ohio	Jin	Triomphant	Vanguard	Borei
Fleet Size (2018)	1(1)/0(2)	14	4(+1 Xia) (3)	4	4	4(+7 Delta) (4)
Crew	95/-	159	-	110	135	130
Length (m)	110/-	170.7	138	138	149.9	170
Displacement (tonnes)	6,000/13,500	19,000	10,000	13,000	14,400	21,800
Beam (m)	11/-	12.8	12.8	12.5	12.8	13.5
Draught (m)	9/-	10.8	8	10.6	12	10
Reactor Power (MW)	85/170	-	-	150	-	190
Speed (knots)	24/25	20+	20+	25	25	29
Torpedo Tubes	6/-	4	6	4	4	6
Missiles Tubes	4/12 (K-4)(5)	24	12	16	16	16

(1) The Arihant is India's only active SSBN, joining the Navy in 2016.

(2) The S-5-Class submarine represents the future SSBN fleet of the Indian Navy, with the first ship planned to be launched by 2030.

(3) In 1987, China built the Xia-Class submarine, which was the first SSBN developed and constructed in Asia.

(4) Russia has one Delta III-Class and six Delta IV class SSBNs, in addition to its four Borei-Class SSBNs.

(5) Indian SSBNs are designed to have missile tubes that can be fitted with either 4 K-15 SLBMs or 1 K-4, K5, or K-6 SLBM per tube.

INS ARIHANT (S-2)

Commissioned in August 2016, the INS Arihant was designed from a Russian Project 971 Akula-Class submarine and constructed for an estimated $2.9 billion SSBN at the Visakhapatnam Ship Building Center (SBC).[29],[30] The BRAC developed the 85 MW pressurized water reactor to allow the Arihant to stay underwater and undetected for extended amounts of time. The ship is small compared to the U.S. Ohio-Class, as the Arihant has a displacement of 6,000 tonnes and a length of 110 m. However, the Arihant has a comparable maximum speed of 24 knots when compared to most SSBNs. The Arihant lags behind in armament as it has four launch tubes that are capable of carrying 4 K-4s or 12 K-15s (three per tube), with subsequent SSBNs likely having eight launch tubes.[31] Despite the Arihant having launched K-15 missiles and conducting deterrent patrol, sources state that Arihant will mainly function as the Indian nuclear submarine fleet prototype and training platform. The Arihant still does not match up in almost every category including size, armament, and reactor power.

23. "Arihant Class Submarine," Naval Technology, May 1, 2017, https://www.naval-technology.com/projects/arihant-class/.
24. Unnithan, " A Peek into India's Top Secret."
25. China Power Team, "Does China have an effective sea-based nuclear deterrent?"
26. Mitsopoulos, "All the Nuclear Missile Submarines in the World in One Chart."
27. "The world's biggest submarines," Naval Technology, October 21, 2013, https://www.naval-technology.com/features/feature-the-worlds-biggest-submarines/.
28. Missile Defense Project, "Missiles of the World," Missile Threat, Center for Strategic and International Studies, November 30, 2016, https://missilethreat.csis.org/missile/.
29. Franz-Stefan Gady, "India Test Fires Short-Range Ballistic Missiles From Submerged Sub," *Diplomat*, August 22, 2018, https://thediplomat.com/2018/08/india-test-fires-short-range-ballistic-missiles-from-submerged-sub/.
30. "Arihant Class Submarine," Naval Technology.
31. Gady, "India Test Fires Short-Range Ballistic Missiles From Submerged Sub."

INS ARIGHAT (S-3)

On November 19, 2017, India's SBC launched a second SSBN, the INS Arighat, which is undergoing sea trials and is planned to be commissioned in 2020 or 2021.[32] This SSBN is a larger version of the Arihant, is about 10 m longer, displaces 1,000 more tonnes, and has a slightly more powerful reactor.. The Arighat has double the number of missile tubes: eight launch tubes that will be capable of carrying eight K-4s or 24 K-15s (three per tube). The Arighant is planned to be equipped with more advanced sensor technology than the Arihant. After the Arighat was launched to sea, India began construction on two more SSBNs, designated S4 and S4*, at the SBC drydock in Visakhapatnam with plans to launch in 2020 and 2022 respectively.[33]

FUTURE SSBN FLEET: S5

By the mid-2020s, the DRDO plans to build four more SSBNs, designated the S5class, which will be twice the size of the Arihant at 14,900 tonnes and have double the payload capacity of 12 SLBMs. Also, these submarines will have a reactor power of about 190 MW, which is three times the power of the Arihant's reactor.[34] These submarines are planned to carry K-6 missiles with a range of 6,000 km. India is pursuing an effective triad with at least four reliable SSBNs (i.e., S5-class) that will go on rotating deterrence patrols. In addition, India plans to complement their SSBNs with a fleet of six 6,000 tonnes SSNs, which are under construction in a new design facility in Gurgaon. The S5-class will be more comparable to British, French, and Chinese SSBNs in terms of maximum speed, size, and reactor power but will still lag behind in payload capabilities. The S5 will not be able to compete with the U.S. or Russian SSBNs, but it may not be necessary for India to field SSBNs that are that large or fast.

OPERATIONAL ISSUES

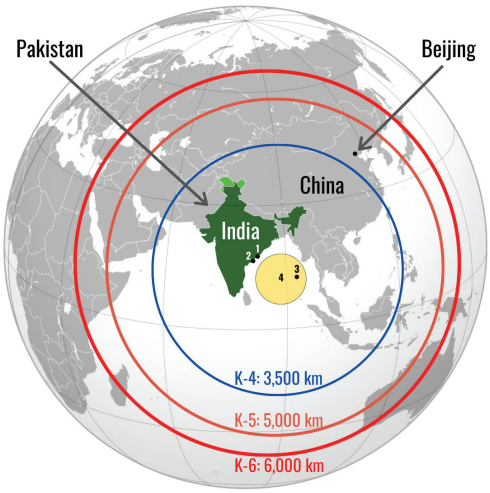
It will take decades for India to build the knowledge and competency in order to effectively operate and maintain their ships. Recently, in February 2017, the Arihant sustained major damage and was out of service for about 10 months for repairs.[35] Seawater flooded into the SSBN's propulsion compartment after an external hatch was left open from human error, which resulted in severe damage. Extensive repairs were needed, which included cutting out and replacing piping as corrosive seawater had damaged the integrity of the pressurized piping that cools the nuclear reactor.[36] Additionally, India's only SSN, Chaka, suffered damage to sensitive sonar equipment due to an accident while in dry dock. Russia ended up charging India 20 million USD to pay for repairs in February 2018. India is relatively new as a nation to operate naval nuclear power plants; there is a learning curve for operators, engineers, and officials to improve their management and execution of the reactors.

FUTURE SSBN HOMEPORT: INS VARSHA

By 2022, India plans to complete the construction of the first phase of a new submarine base, INS Varsha, at an estimated cost of $4.3 billion.[37] Varsha is strategically located on India's eastern coast near Rambilli and 50 km south of Visakhapatnam, the site of nuclear ship construction. The hidden base will homeport both SSNs and SSBNs in an underground facility built into the Rambilli hills with

32. Franz-Stefan Gady, "India Launches Second Ballistic Missile Sub," *Diplomat*, December 13, 2017, https://thediplomat.com/2017/12/india-launches-second-ballistic-missile-sub/.
33. Unnithan, "A Peek into India's Top Secret."
34. Ibid.
35. Dinakar Peri and Josy Joseph, "INS Arihant Left Crippled after 'accident' 10 Months Ago," *Hindu*, January 8, 2018, https://www.thehindu.com/news/national/ins-arihant-left-crippled-after-accident-10-months-ago/article22392049.ece.
36. Jared Keller, "A Foreign Navy Screwed Up Its New $3 Billion Nuclear Missile Sub By Leaving Its Hatch Open," *Task & Purpose*, January 9, 2018, https://taskandpurpose.com/indian-navy-nuclear-submarine-hatch.
37. Unnithan, "A Peek into India's Top Secret."

open water access via a tunnel.[38] The second phase of Varsha will expand the base by constructing facilities for recharging, degaussing, and technical support areas.[39] The figure below shows Varsha's strategic location with ranges of various missiles in development.



Source: Ssolbergj/Wikimedia Commons (CC BY-SA 3.0)

Figure 1: The Importance of the Bay of Bengal to India Sea-based Nuclear Deterrence.[40]

(1) The Ship Building Center (SBC) for constructing a nuclear submarine fleet at Visakhapatnam;

(2) The Nuclear submarine base, INS Varsha, near Rambilli for homeporting SSNs and SSBNs;

(3) Andaman and Nicobar Islands for testing SLBMs; and

(4) An approximate patrol area for the Indian SSBN fleet to hide and strike adversaries.

Within two nautical miles of leaving Varsha, the submarines can immediately dive deep and disappear as the Indian continental shelf steeply drops into the Bay of Bengal. In contrast, a submarine leaving the Indian west coast must sail out 80 nautical miles into the Arabian Sea. Thus, Indian SSBNs will eventually be able to depart and stay undetected for months, providing strategic deterrence. In the next section, this article will explore the range implications of Indian missiles that are in operation and under development.

SLBN CAPABILITIES AND DEPLOYMENT

India is estimated to have produced 130 to 140 nuclear warheads, which are used across several naval, two aircraft, and four land-based ballistic missile systems.[41] India produces plutonium via its Dhruva reactor and enrichment facility for nuclear weapons. Tables 2 and 3 provide the specifications for a given type of SLBM.

38. Saurav Jha, "India's Undersea Deterrent," *Diplomat*, March 30, 2016, https://thediplomat.com/2016/03/indias-undersea-deterrent/.
39. Anuthuti Vishnoi and Manu Pubby, "India's nuclear submarine base gets a big boost—thanks to Narendra Modi Govt," *Print*, January 2018, 10, https://theprint.in/defence/big-boost-india-secret-nuclear-submarine-base/27617/.
40. Unnithan, "A Peek into India's Top Secret."
41. Hans M. Kristensen et al., "Indian Nuclear Forces," *Bulletin of the Atomic Scientists* 74, no. 6 (2018): 361-366.

Table 2: Comparison of Indian SLBMS.[42,43,44]

MISSILE	DHANUSH	K-15	K-4	K-5	K-6
Other Name	-	Sagarika	Shaurya	-	-
Year Deployed	2010	2018	Developing	Developing	Developing
Length (m)	8.5	10.8	12	Unknown	12
Diameter (m)	1.0	0.8	0.8	Unknown	2.5
Weight (kg)	5,600	5,500-6,300	17,000	Unknown	
Payload (kg)	500-1,000	500-800	2,000	2,000	3,000
Payload (MIRV)[45]	1	1	1	1	3-6
Warhead (kT)	-	-	200-250	-	-
Propulsion	Single-stage liquid propellant	Two-stage solid propellant	Two-stage solid propellant	Three-stage solid propellant	Three-stage solid propellant
Range (km)	250-400	700-750	3,000-3,500	5,000	6,000
CEP (m)[46]	25-50	40	20-30	Not tested	Not tested

Table 3: Comparison of Indian SLBMs with Those of Other Nations.[47,48]

COUNTRY	INDIA	US/UK	CHINA	FRANCE	RUSSIA	
Missile	K-15	K-6	D-5	JL-2	M-51	SS-N-32
Other Name	Sagarika	-	Trident II	Ju Lang-2	-	Bulava
Year Deployed	2018	Developing	1990	2015	2010	2013
Quantity/Ship	12		20/16	12	16	16
Length (m)	10.8	12.0	13.4	13.0	13.0	12.1
Diameter (m)	0.8	2.5	2.1	2.0	2.4	2.0
Weight (kg)	5,500-6,300		58,500	42,000	53,000	36,800
Payload (kg)	500-1000	3,000	-	1,050-2,800	1,350	1,150
Payload (MIRV)	1	4-6	1-8	1 or 3-8	4-6	1-6
Warhead (kT)	-	-	-	20-150	150	100-150
Propulsion	Two-stage solid propellant	Three-stage solid propellant	Three-stage solid propellant	Three-stage solid propellant	Three-stage solid propellant	Three-stage solid propellant
Range (km)	750	6,000	7,360	8,000	8,000	8,300
CEP (m)	40	-	-	150-300	350	250-300

42. Unnithan, "A Peek into India's Top Secret."
43. Missile Defense Project, "Missiles of India," *Missile Threat*, Center for Strategic and International Studies, June 14, 2018, last modified June 15, 2018, https://missilethreat.csis.org/country/india/.
44. Hemant K. Rout, "DRDO on long range Pralay, K5 to stalemate China soon," *New Indian Express*, December 15, 2018, http://www.newindianexpress.com/states/odisha/2018/dec/15/maiden-trial-of-pralay-k5-likely-soon-1911623.html.
45. A multiple independently targetable reentry vehicle (MIRV) is a missile payload containing several warheads, each capable of being aimed to hit a different target.
46. Circular error probable (CEP) is a measure of a weapon system's precision. It is defined as the radius of a circle, centered on the mean, whose boundary is expected to include the landing points of 50 percent of the rounds.
47. "Trident II (D5) Missile," U.S. Navy, May 15, 2019, https://www.navy.mil/navydata/fact_display.asp?cid=2200&tid=1400&ct=2.
48. Missile Defense Project, "Missiles of the World."

DHANUSH

The Dhanush is a short-range SLBM that is a ship-based variant of the Prithvi-II land-based ballistic missile.[49] The Dhanush was configured to be launched from the back of two Sukanya-class patrol vessels, the INS Subhadra and the INS Suvarna, with each ship having a payload of two missiles. Currently, the two Sukanya-class ships are homeported at the Karwa naval base on the Indian west coast. The Dhanush missile is operational and was tested twice in 2016 and once again in 2018. As the Dhanush missile has a very short range, an Indian ship would have to travel dangerously close to an enemy's shoreline to strike a city or target. One realistic coastal target would be Pakistan's largest city, Karachi. India will probably phase out the Dhanush missile soon in favor of longer-range missile systems as its short range is indicative of serving as a developmental and testing system.

K-15 (SAGARIKA)

India's primary operating SLBM seems to be the recently tested K-15, which has a relatively short range, but it is longer than the Dhanush. On August 11 and 12, 2018, the INS Arihant successfully test fired three K-15 SLBMs for the first time from a submerged position 10 km off the Visakhapatnam coast.[50] These tests resulted in the missiles hitting their targets with close to zero CEP accuracy. If Indian submarines armed with the K-15 sailed around the southern tip to the Arabian sea, they would threaten and could strike targets in southern Pakistan, which includes the largest city of Karachi. Realistically, unless India wants to signal to Pakistan, it would not make sense for India to sail an SSBN close enough to hit Pakistani coastal targets, as this could increase tensions. Also, in order to threaten Chinese coastal targets, Indian ships would have to reach the South China Sea via the Singapore Strait. Thus, the K-15 missile seems like a predecessor missile to develop the rocket technology for more accurate and longer-range missiles as the K-4 missile is being concurrently developed.

K-4 (SHAURYA)

India is developing the longer-range K-4 (Shaurya) SLBM, which has been tested four times, with a recent successful launch on March 31, 2016, and a failed launch on December 17, 2017.[51] A DRDO scientist working on the K-4 missile project stated that the missile systems had undergone successful tests and they wanted "to achieve close to zero" CEP accuracy.[52] When the K-4 SLBM becomes operational, India will possess more effective deterrence when an SSBN is on patrol hiding in the Bay of Bengal. An Indian SSBN would threaten and could strike targets in all of Pakistan and most geographic regions in China, including Shanghai and Hong Kong. However, Beijing is outside the 3,500 km range of the K-4 and thus an Indian SSBN would have to sail into the South China Sea via the Singapore Strait to reach that target.

FUTURE MISSILE DEVELOPMENT: K-5 AND K-6

The DRDO is preparing for the initial test of the K-5 missile, its long-range SLBM.[53] The K-5 missile is reported to be the fastest missile in the K Series project and able to deceive enemy radar,

49. Kristensen et al., "Indian Nuclear Forces," 361-366.
50. Hemant K. Rout, "Nuke-capable submarine-launched missile operationalised, India in select triad club," *New Indian Express*, August 21, 2018, http://www.newindianexpress.com/specials/2018/aug/19/nuke-capable-submarine-launched-missile-operationalised-india-in-select-triad-club-1859992.html.
51. Missile Defense Project, "Indian K-4 SLBM Test Fails," *Missile Threat*, Center for Strategic and International Studies, modified June 15, 2018, https://missilethreat.csis.org/indian-k-4-slbm-test-fails/.
52. Hemant K. Rout, "Longest Range Ballistic Missile All Set for Undersea Launch," *New Indian Express*, December 10, 2013, http://www.newindianexpress.com/states/odisha/2013/dec/10/Longest-Range-Ballistic-Missile-All-Set-for-Undersea-Launch-548253.html.
53. Rout, "DRDO on long range Pralay."

adding serious lethality to the Indian strategic deterrence. The initial missile test is planned for a small range to be flight tested from a submersible pontoon launcher in the Bay of Bengal off the Visakhapatnam coast. This would validate the incorporation of new technologies into the missile incorporated in the system. The K-5 is planned to be armed on the future class of S4 SSBNs, which are currently being developed. A successful testing of the K-5 missile technologies will lay the foundation for a longer-range version known as the K-6 SLBM missile.[54] By the mid-2020s, India could have four rotating SSBNs on patrol that may be armed with K-5 or K-6 SLBMs. This would stabilize the sea leg of the triad and result in India possessing effective nuclear deterrence and second-strike capability. From the Bay of Bengal, an Indian SSBN would threaten and could strike targets in all of Pakistan and China.

CONCLUSION

In November of 2018, India's INS Arihant SSBN successfully completed a month-long deterrent patrol with SLBMs and established India's nuclear triad. In a traditional nuclear triad, SSBNs comprise the sea leg, provide the most reliable and survivable means of nuclear deterrence, and allow the attacked nation to retaliate with a second strike. However, even though India seems to have a nuclear triad, there are several challenges for employing an effective SSBN, including having operational stealth capability; carrying reliable, capable, and accurate SLBMs; and possessing a survivable and resilient command and control structure.

India's largest challenge is only having one commissioned SSBN, which logistically cannot operate and provide strategic deterrence at all times due to training, maintenance, etc. An adversary could locate and disable the Arihant with a first strike. Additionally, the Arihant does not seem as large or capable as SSBN classes for other nations due to its size, speed, and payload. The payload can only house one of two operational SLBM systems, of which a maximum of 12 missiles can be loaded into the Arihant's missile compartment. These SLBMs do not give India much deterrence capability, as SSBNs can only hit coastal targets within ranges of 250 to 750 km. India is planning to develop longer-range K-6 missiles (6,000 km) that will provide sufficient deterrence capability being able to strike targets in all of Pakistan and most of China from the Bay of Bengal.

A fleet of four rotating SSBNs is suggested to provide a continuous patrol of deterrence. Thus, if India were eventually able to deploy multiple SSBNs at once, it would be in a position to effectively deter and retaliate. By the mid-2020s, India plans to build four more SSBNs, designated the S5-class, which will be similar to SSBNs of other nations in size, speed, and reactor power. Additionally, India plans to complement its SSBN fleet with six SSNs that will be equipped with torpedoes and conventional cruise missiles. The reactor is critical to India's future deterrence and national security posture as it provides nuclear-powered submarines with reliable propulsion and endurance to conduct their respective missions. Lastly, India's new submarine base, Varsha, will provide both SSNs and SSBNs in an underground homeport to maintain anonymity and stealth. Thus, India's SSBN fleet will eventually be able to depart and stay undetected for months providing strategic deterrence.

At the moment, the India SSBN fleet is not very capable and does not provide effective deterrence, especially against their adversaries of Pakistan and China. The Navy only has a single lack-luster SSBN, which experiences maintenance issues and carries a small payload of short-range nuclear missiles. However, India is developing long-range SLBMs and progressing in nuclear reactor

54. Ibid.

technology and submarine engineering to field effective SSNs and SSBNs. In a decade, the nation could arm a newly built fleet of four rotating S-5 SSBNs armed with the 12 K-6 SLBMs to provide the nuclear deterrence it needs for its national security interests.

Assessing the Impacts of the PLA's Nuclear Modernization Efforts on the Stability of the Taiwan Strait

James H. V. To[1]

ABSTRACT

After seven decades, the complex trilateral relationship between the Republic of China (or Taiwan), the People's Republic of China (PRC), and the United States remains one of the most troublesome, yet dormant, flash points in geopolitics. In the past, the perception of the United States' military superiority played an integral role in maintaining the stability of the Taiwan Strait. However, the People's Liberation Army (PLA) has been rapidly modernizing, diversifying, and integrating new capabilities in both the conventional and nuclear realms. This raises the concern that the status of Taiwan would serve as a catalyst in an unmanageable crisis in the Indo-Pacific. What would happen if Beijing concludes that it must reunify with Taiwan through the use of force, and Washington decides to intervene? The political pressures facing either side are drastically different. This raises two questions about the hypothetical conflict: Would the escalation dynamic in the Taiwan Strait produce necessary conditions for the PRC to alter its nuclear policy and employment strategy? What are some of the possible triggers that could lower the threshold of

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nuclear weapons usage? This paper attempts to shed light on these inquiries as well as assess the effects of PLA nuclear modernization.

WHY SHOULD WE CARE ABOUT TAIWAN?

After the conclusion of the Chinese Civil War in 1949, remnants of the Kuomintang government reestablished the Republic of China on the island of Taiwan. Since then, the PRC has made unification with Taiwan one of its primary political, cultural, and military objectives. In the following decades, the PRC and the United States experienced a number of crises over the existence of Taiwan as a separate political entity. The issue went dormant after the 1972 Shanghai Communique as both the PRC and the United States pushed toward the normalization of the relationship. In time, the de facto existence of Taiwan as an independent state became the inherent status quo. However, with the recent ascension of the PRC, there have been large incentives for the leaders of the Chinese Communist Party (CCP) to clamor for a drastic modification of the status quo. From Beijing's viewpoint, Taiwan is still an integral part of its national sovereignty, albeit in the form of a renegade province. Meanwhile, after two decades of engagement against nonstate actors, the United States has shifted its focus back to the challenges posed by strategic competitors such as Russia and the PRC. In this context, Taiwan re-emerged as a contested issue in U.S.-PRC relations in the region.

After decades of being content with its minimal deterrence posture, the PRC is in the process of establishing a nuclear triad. Why has the CCP decided to pursue such a development at this time? Has the perception of its external security changed drastically? Or is it planning for the inevitable unification with Taiwan, where its nuclear weapons, along with newly acquired conventional capabilities, could play critical roles in deterring a U.S. intervention? Even though the likelihood of a kinetic conflict between the two countries over Taiwan in the near future is relatively low, it is unwise to conclude that such an outcome is unreasonable or to assume that there is little chance that a Taiwan Strait conflict would escalate up to the nuclear realm.

As the PLA continues to strive for advances in its conventional and nuclear capabilities, the dynamics of a potential conflict in the Taiwan Strait could lower the nuclear employment thresholds. At the early stage of the conflict, Beijing could exploit U.S. policymakers' tendencies to gravitate toward risk-averse and conflict-avoidant measures through risk manipulation techniques. Then it could follow with swift and limited conventional conflict to conquer Taiwan. In this instance, what would happen if the United States decides to get involved? While there is little evidence to conclude that the PRC is in the process of abandoning its No First Use (NFU) pledge, sweeping reforms across the PLA would introduce a certain degree of changes to its nuclear strategy. One of those adjustments could be the endorsement of a launch on warning (LOW) posture.[2] This evolution in strategic thinking would place the PRC's nuclear strategy one step closer to its conventional doctrine. Eventually, the Central Military Commission (CMC) would find it irresistible to not assign both a deterrence and a warfighting mission to its nuclear forces. This would be a departure from its traditional nuclear strategy, which is predicated on the PLARF's retaliatory capability after the PRC has already absorbed a nuclear strike.[3] Furthermore, improvements across the nuclear, space, conventional, and information domains would allow

2. Statement of David Santoro, Director and Senior Fellow for Nuclear Policy, Pacific Forum International. See: U.S.-China Economic Security Review Commission. *A 'World-Class' Military: Assessing China's Global Military Ambitions*, 116th Cong., 1st sess. (June 20, 2019).
3. Liping Xia, *China's Nuclear Doctrine: Debates and Evolution* (Washington DC: Carnegie Endowment for International Peace, 2016).

the PLA to put the "integrated strategic deterrence" concept[4] into practice. Paradoxically, these changes could yield both favorable and unfavorable consequences. On a positive note, it could help strengthen strategic stability between the United States and the PRC. However, the downside is an inadvertent arms race that might weaken the crisis stability in any future confrontation in the Taiwan Strait.

NUCLEAR WEAPONS AND THE TAIWAN STRAIT

Essentially, the PRC derived large parts of its justifications for the nuclear weapons program from past confrontations in the Taiwan Strait. It began with the First Taiwan Strait Crisis. While the United States was debating whether or not to sign a Mutual Defense Treaty with the ROC, Chiang Kai-shek deployed his troops to the KMT-controlled islands of Matsu and Kinmen (Quemoy) in August of 1954. In September, the PRC responded by shelling Matsu and Kinmen and expanded the bombardment to the Dachen Islands. In early 1955, the U.S. Congress passed both the U.S.-ROC Mutual Defense Treaty and the Formosa Resolution which authorized the power to the Eisenhower administration to defend Taiwan and the offshore islands.[5] While the main intent of the security pact was to deter an invasion of Taiwan, the treaty also sought to alleviate the PRC's fear of a U.S.-backed invasion of mainland China by restricting the United States' commitment only to the islands of Taiwan and Pescadores (Penghu).[6] During this crisis, the faltering trust in the Soviets' extended nuclear deterrence was further put into doubt as it failed to fully support the PRC's efforts to unify with Taiwan.[7] Meanwhile, the United States was threatening the use of nuclear weapons to prevent further advances by the PLA, as it had already taken the Yijiangshan Islands.[8] The outcome of the U.S. attempt at nuclear coercion was the temporary cessation of the bombardment of the islands controlled by the ROC. For the United States, the lesson learned was that brinkmanship, along with the backing of nuclear and conventional superiorities, would allow it to extract a political victory without risking large numbers of U.S. troops. For the PRC, the First Taiwan Crisis was an indicator that it must pursue an indigenous nuclear weapons program.

The trend of nuclear buildup continued in the Taiwan Strait. By 1958, the United States stationed the dual-capable Matador cruise missiles and the Nike-Hercules surface-to-air missile batteries in Taiwan.[9] Later that year, the PLA resumed artillery bombardment of the Kinmen and Matsu islands, which prompted the Second Taiwan Strait Crisis. Because the defense treaty of 1954 did not extend the United States' commitment to the islands of Matsu and Kinmen, the Second Taiwan Strait Crisis was seen as a test of the Eisenhower administration's resolve to defend Taiwan rather than an attempt by the PRC to occupy those smaller islands. During this time, the United States deployed 8-inch howitzers capable of projecting nuclear artillery shells. However, it was not publicly declared that the nuclear artillery shells were deployed with these howitzers.[10] Subsequently, there were two

4. "Integrated strategic deterrence" composes of militarized capabilities such as nuclear, conventional, space, and cyberwarfare along with nonmilitary tools such as diplomatic, economic, and scientific and technological strength. See also Michael, S. Chase and Arthur Chan, *China's Evolving Approach to "Integrated Strategic Deterrence"* (Santa Monica, CA: RAND Corporation, 2016).
5. Abram N. Shulsky, *Deterrence Theory and Chinese Behavior* (Santa Monica, CA: RAND Corporation, 2000), 10.
6. "Mutual Defense Treaty Between the United States and the Republic of China; December 2, 1954," ratified February 9, 1955, *The Avalon Project*, http://avalon.law.yale.edu/20th_century/chin001.asp.
7. Xu Weidi, "China's Security Environment and the Role of Nuclear Weapons," in *Understanding Chinese Nuclear Thinking*, ed. Li Bin and Tong Zhao (Washington DC: Carnegie Endowment for International Peace, 2016), 23.
8. Gordon H. Chang, "To the Nuclear Brink: Eisenhower, Dulles, and the Quemoy-Matsu Crisis," *International Security* 12, no. 4 (Spring, 1988): 96-123.
9. Melvin Gurtov, "The Taiwan Strait Crisis Revisited: Politics and Foreign Policy in Chinese Motives," *Modern China* 2, no. 1 (January, 1976): 49-103
10. Gurtov, "The Taiwan Strait Crisis Revisited," 75.

observations that came out of the second crisis. The first was that the PRC gamble paid off in that the United States did not want to further escalate the crisis by striking artillery sites on mainland China.[11] The second was that the CCP's leadership—in this case, Mao Zedong—was willing to risk escalation to mobilize political support to overcome a domestic challenge such as the Great Leap Forward.[12]

In 1979, Washington ended its formal relationship with Taipei. The 1979 Taiwan Relations Act (TRA) took the place of the 1954 Mutual Defense Treaty. Congruent with the spirit and intent of the 1954 security pact, the TRA sought to maintain peace, security, and stability in the Western Pacific, albeit through a very different method. Through the TRA, the United States adopted a position of strategic ambiguity rather than clarity over its involvement in the Taiwan Strait. On one hand, the act terminated official relations between Washington and Taipei.[13] On the other hand, it specified that the United States will continue to provide Taiwan with arms of a defensive character and maintain the capacity to resist any resorts to force or other forms of coercion that would jeopardize the security, or the social or economic system, of the people of Taiwan.[14] By not revealing its specific course of action, the uncertainty of U.S. involvement in a conflict in the Taiwan Strait sought to deter the PRC from attacking Taiwan and to deter Taipei from acts that could warrant harsh reactions from Beijing.[15]

An unintended consequence of the shift from strategic clarity to strategic ambiguity was the numerous tests of Washington's resolve by Beijing. One of those occurrences became the next crisis in 1996 when the PRC conducted amphibious military exercises and test-launched the dual-capable Short Range Ballistic Missile (SRBM) DF-15/CSS-6 off the coast of Taiwan.[16] The United States' response was to send two aircraft carrier battle groups to the region as a demonstration of its resolve to uphold the TRA.[17] During the span of the Third Taiwan Strait Crisis, the PRC also carried out two underground nuclear tests[18] Another peculiar instance was a disquieting conversation[19] between a PRC official and the former assistant secretary of defense Chas W. Freeman Jr.[20] In a deterrence context, the intent of the message was to communicate that if the PLA was to move against Taiwan, it could operate without the fear of an intervention or nuclear coercion as in past crises. However, this message could also be taken as an indirect nuclear threat against a U.S. city and the PRC's willingness to escalate up to the nuclear realm over the political status of Taiwan. Throughout these events, the United States enjoyed a comfortable advantage in conventional and nuclear capabilities against the PRC, yet these sorts of crises in the Taiwan Strait still managed to materialize as a reminder of the perpetual specter of an inadvertent conflict due to miscalculations between Washington, Taipei, and Beijing.

11. Shulsky, *Deterrence Theory and Chinese Behavior*, 11.
12. Ibid., 39.
13. U.S. Congress, *Taiwan Relations Act: Conference Report to Accompany H.R. 2479*, (Washington DC: U.S. Government Print Office, 1979).
14. Ibid.
15. Eric Gomez, *A Costly Commitment Options for the Future of the U.S.-Taiwan Defense Relationship* (Washington, D.C.: Cato Institute, 2016), https://object.cato.org/sites/cato.org/files/pubs/pdf/pa800.pdf.
16. Yuan-kang Wang, "Taiwan Public Opinion on Cross-Strait Security Issues Implications for US Foreign Policy," *Strategic Studies Quarterly* 7, no. 2. (Summer, 2013): 93-113.
17. Andrew Scobell, *Show of Force: The PLA and the 1995-1996 Taiwan Strait Crisis* (Stanford, CA: Stanford University Asia/Pacific Research Center, 1999), https://fsi-live.s3.us-west-1.amazonaws.com/s3fs-public/Scobell.pdf.
18. Seith Faison. "China Sets Off Second Nuclear Test in 3 months," *New York Times*, August 17, 1995.
19. In conversation over the potential U.S. response to an attack on Taiwan that took place in 1996, the then Lt. Gen. Xiong Guangkai, deputy chief of the PLA's General Staff, told Mr. Freeman: "In the 1950s, you three times threatened nuclear strikes on China, and you could do that because we couldn't hit back. Now we can. So you are not going to threaten us again because, in the end, you care a lot more about Los Angeles than Taipei."
20. Barton Gellman, "U.S. and China Nearly Came to Blows in '96," *Washington Post*, June 21, 1996, https://www.washingtonpost.com/archive/politics/1998/06/21/us-and-china-nearly-came-to-blows-in-96/926d105f-1fd8-404c-9995-90984f86a613/?utm_term=.f6654efeb273.

CHALLENGES TO DETERRENCE IN THE STRAIT

Currently, there exists a dual deterrence dyad in the Taiwan Strait. The first involves the U.S. effort to deter the use of force by the PRC to reunify with Taiwan. The second is the PRC's deterrence against the government of Taipei from formalizing its independent status. The interactions by different elements within these dyads inadvertently generate the perpetual cycle of tensions and escalatory actions in East Asia. While there are other important variables that require constant calibration between these two dyads, three core factors that play integral roles in the stability in the Taiwan Strait are the asymmetry of conventional capabilities, the shifting levels of interests between the involved parties, and the balance of terror in the nuclear realm.

The effectiveness of deterrence in the Strait is a direct product of the mutual understanding that the United States has the ability and the resolve to impose sufficient costs that would outweigh any benefits the PRC could obtain. Therefore, the belief that the United States would intervene in response to an invasion by the PLA remains one of the most important components in the CCP's assessment of its Taiwan strategy. However, due to the TRA's constraints, the biggest challenge for Washington is making its commitments credible while maintaining enough space to maneuver out of a potential crisis if deemed necessary. This unique rhetorical challenge creates a sense of uncertainty that encourages belligerent parties to enter a contest of resolves that could result in a brinkmanship scenario that could spiral out of control.

While the asymmetry in conventional capability is vital to the stability of the Taiwan Strait, another important component to consider is the balance of interest between Beijing and Washington. The issue of Taiwan does not rank equally in Washington and Beijing from a national interest standpoint. To Xi Jinping, Taiwan is an "inevitable requirement" in the CCP's quest to achieve national sovereignty and to restore the great Chinese nation.[21] The PRC's interest in unification remains consistent despite changes in leadership. The longer it waits, the more pertinent the issue becomes in the eyes of the Chinese people and to the CCP leadership. For the United States, Taiwan constitutes a part of its reputational interest in the larger global competition. As for the U.S. public, there is a lack of awareness and comprehension about the issue.[22] This problem is further exacerbated due to Taiwan's ambiguous status and the PRC's strong influence in the rhetoric surrounding this issue.

Since the late 1970s, the CCP's top priorities have been the PRC's economic performance and societal stability.[23] While Taiwan continues to prevail as one of its most sensitive issues, Beijing's interest in unification has not been compelling enough to warrant the risk associated with challenging the status quo. Because the CCP's political legitimacy is directly tied to its ability to provide public goods, it is able to mobilize Chinese society toward one common goal: endless economic growth.[24] However, after a decade of rapid growth, recent reports of the PRC's economic performance have shown signs of stagnation.[25] Ironically, the proven solution to escape such a quandary is to initiate massive economic and political reforms that could accelerate the formation of a democratic movement

21. "Xi Jinping says Taiwan 'must and will be' reunited with China," BBC, January 2, 2019, https://www.bbc.com/news/world-asia-china-46733174.
22. Richard Winke, and Kat Devlin, "As Trade Tensions Rise, Fewer Americans See China Favorably," Pew Research Center, August 28, 2018, https://www.pewresearch.org/global/2018/08/28/as-trade-tensions-rise-fewer-americans-see-china-favorably/.
23. Congressional Research Service, *China's Economic Rise: History, Trends, Challenges, and Implication for the United States*, (Washington DC, 2019), 5.
24. William Overholt, *China Crisis of Success* (Cambridge, United Kingdom: University Printing House, 2018), 42
25. Wei Chen, Xilu Chen, Chang-Tai Hsieh, and Zheng (Michael) Song, *A Forensic Examination of China's National Accounts* (Washington DC: Brooking Institute, 2019), 27.

on mainland China.[26] Taiwan and South Korea, which both faced similar predicaments, chose to restructure their governments. The outcome was a transformation of Taipei and Seoul's authoritarian governments to their current electoral systems. Due to the potential risks to its political survival, it is unlikely that the CCP leadership will make the necessary political restructurings that are often crucial to economic reform.[27]

If the PRC's economic pattern continues to hold, the CCP could find itself in a position where it must replace its current methods to garner political support. Based on recent rhetoric from Xi Jinping, the CCP will rely substantially on the nationalistic tendency to promote Chinese interests internationally and to maintain social stability domestically. Previously unsolved problems associated with national sovereignty, such as the Taiwan issue, will reemerge as contested topics among all echelons of the CCP and Chinese society. While it is challenging to accurately predict how Xi Jinping will react in regard to Taiwan, it is safe to assess that he does not wish to be the leader who would lose the island. Consequently, this creates a strong incentive for the CCP to overplay its hand in signaling its resolve. This results in constant provocations that escalate political tensions, military activities, and information operations to inhibit the potential breakaway of Taiwan. Ironically, the effects of these signaling attempts have actually forged a deeper bond between Taipei and Washington. This creates the perception that Beijing's deterrence efforts have not been strong enough. In time, this dynamic might solidify future CCP resolve to the point that their interests and political stakes become strong enough that they are no longer deterrable. This would accelerate the demise of the status quo and lead to a dangerous confrontation between all belligerent parties.

The final factor is the balance of terror in the nuclear realm. The main difference between U.S. and PRC nuclear doctrines and developmental processes is that the former focuses on nuclear superiority while the latter constrains itself to be content with minimal deterrence. Since its initial experience with the coercive effects of nuclear weapons in the 1950s, the PRC's strategic thinking surrounding this class of weapon has fixated on its political utilization. Rather than to support warfighting or escalation dominance purposes, the focus of the PRC's nuclear weapons program has been to address its concerns with nuclear coercion, to deter the advent of an existential threat, and to inhibit the limited use of such weapons by an adversarial force in a conventional conflict.[28] For the United States, the interest in nuclear superiority has not stopped at its warfighting capability but also is seen as a tool to avoid overt conflict by stopping, or perhaps winning, by turning to "competition in risk taking" approach.[29] Arguably, the United States solved the last three Taiwan Crises by turning to the elements of brinkmanship. In a future Taiwan scenario, the PRC would not commit the same mistakes as in the past. Therefore, the PRC's interest in nuclear modernization does not only rest with improving its second-strike capability, but also in the capacity to engage in some sort of bargaining dynamics with the United States on equal footing. If the PRC can achieve deterrence on the highest level, the outcome of the conflict would rest on its perceived conventional and informational warfare capabilities to convince U.S. constituents and political leaders that the cost of defending Taiwan severely outweighs its benefits.

26. Overholt, "China Crisis of Success," 202.
27. George Magnus, *Red Flags: Why Xi's China Is in Jeopardy* (New Haven, CT: Yale University Press, 2018), 205.
28. Heginbotham et al., *China's Evolving Nuclear Deterrent* (Santa Monica, CA.: RAND Corporation, 2017), 28.
29. Mathew Kroenig, "Nuclear Superiority and the Balance of Resolve: explaining Nuclear Crisis Outcomes," *International Organization* 67, no.1 (Winter 2013): 141-171.

THE PLA'S NUCLEAR MODERNIZATION PROCESS

Lying at the core of the PRC's nuclear modernization program is a concern over the United States' perceived attempts to further degrade the mutually vulnerable relationship. The CMC chooses the qualitative improvement of its nuclear forces over the quantitative. Continuous technological advances in both the nuclear and conventional realms could lead to the development of capabilities associated with a second-strike approach that has embraced nuclear warfighting or counterforce targeting.[30] With its current stockpile and delivery systems, the PRC views itself as being at a major disadvantage to the United States' strategic forces. This problem was exacerbated by its distrust in the intention of the United States' ballistic missile defense (BMD) and Prompt Global Strike (PGS) capabilities. These two programs are often seen as part of a larger U.S. strategy to achieve "absolute security," thus permitting the United States to act preemptively in a cross-domain context.[31] To address its concern over assured retaliation, the PLA must overcome three challenges: the survivability of its delivery platforms, evasion of missile defense systems, and detection of an incoming strike. With the possibility of having to serve both the deterrence and the warfighting missions in the future, the current focus of the PLA's nuclear modernization process is to enhance the diversity, flexibility, and survivability of its forces.

Although the PLARF will remain the core component of the PRC's nuclear force, the need for a greater diversity in the delivery systems will expand the strategic and regional nuclear missions to the PLAN and the PLAAF. The requirement for enhanced survivability and penetrating capabilities has driven crucial technological developments such as hypersonic glide vehicles (HGVs), ballistic missile submarines (SSBNs) and long-range strategic bombers with air-launched cruise missiles (ALCMs), and air-launched ballistic missiles (ALBMs).[32],[33] To support its traditional kinetic elements, the PLA is also advancing its early-warning and information warfare capabilities through the People's Liberation Army Strategic Support Force (PLASSF).

THE PEOPLE'S LIBERATION ARMY NAVY

To enhance its second-strike capability, the PLAN will build upon its experiences of operating its existing fleet of Type 094/Jin-class SSBNs. The PLAN currently possesses an inventory of six Type 094 SSBNs that could carry up to 12 JL-2/CSS-NX-14 submarine-launched ballistic missiles (SLBMs).[34] However, in order to conduct strategic deterrence patrols, the PLAN will probably keep its nuclear warheads mated to the SLBMs unless it plans to only load its SSBNs with nuclear-armed SLBMs during periods of heightened tension. This would go against the desire for a more survivable sea-based deterrent. In that case, it would decrease the CMC's assurance in the PLA's retaliatory capability. This low confidence would severely impact its stability during a nuclear crisis. On the other hand, if the PLAN does indeed keep its SLBMs mated with nuclear warheads, this development could have cascading effects toward the PLARF and PLAAF. For its day-to-day launch posture, the PLARF maintains a strict priority of centralized command and control over its nuclear warheads at the expense of rapidity. A consequence of this very low state of readiness is that the

30. Heginbothm, et al., *China Evolving Nuclear Deterrent*, 119.
31. Lora Saalman, *Prompt Global Strike: China and the Spear* (Honolulu, HI: Daniel K. Inoyue Asia-Pacific Center for Security Studies, 2014), 4.
32. Defense Intelligence Agency, *Global Nuclear Landscape* (Washington D.C.: Defense Intelligence Agency, 2018), VII.
33. Ankit Panda, "Revealed: China's Nuclear-Capable Air-Launched Ballistic Missile," *Diplomat*, April 10, 2018, https://thediplomat.com/2018/04/revealed-chinas-nuclear-capable-air-launched-ballistic-missile.
34. Mike Yeo, "China completing more ballistic missile subs, with plans for a new version," *Defense News*, May 6, 2019, https://www.defensenews.com/global/asia-pacific/2019/05/06/china-completing-more-ballistic-missile-subs-with-plans-for-a-new-version/.

majority of its warheads are kept in a centralized location and would only be transported to the launch facility if the need arose.[35] If the PLAN can mate its warheads on the current JL-2s and the future JL-3s, the PLARF could also demand that it should be able to conduct deterrence operations with the mobile launchers for the sake of enhanced survivability through mobility, concealment, and dispersed deployment.

THE PEOPLE'S LIBERATION ARMY AIR FORCE

To complete the PLA's nuclear triad, the PLAAF was re-assigned the nuclear mission in 2018.[36] While there is little information on its strategic mission, the PLAAF will continue to rely on the latest variant of its H-6 Badger platforms, the H-6K and the H-6N, to employ standoff weapons such as the CJ-20 ALCM.[37] The CJ-20 is the air-launched variant of the dual-capable Land-Attack Cruise Missile (LACM) CJ-10/DH-10.[38] Future efforts to diversify the PLAAF nuclear delivery systems include the development of stealth bombers. Another possible addition to the PLAAF's arsenal could be the CH-AS-X-13, the likely air-launched ballistic missile (ALBM) variant of the dual-capable DF-21/CSS-5 medium-range ballistic missile (MRBM).[39] The eventual integration of these systems will not only enhance the PLA's ability to project power beyond the second island chains, but also to further solidify its anti-access/area denial strategy to signal the CCP's resolve to deter and to compel potential adversaries. Additionally, the increased competition for greater roles and resources within the nuclear mission between the PLARF, PLAN, and PLAAF could generate a deeper discussion on the PRC's outlook on the utilization of its nuclear arsenal. Some potential outcomes might include the adoption of LOW or a greater clarity on what the PLA should consider an attack in light of its NFU policy.

THE PEOPLE'S LIBERATION ARMY ROCKET FORCE

Even though the PLA is striving toward a triad, the PLARF will remain the core component of the PRC's nuclear deterrence. While its current inventory consists of a mixture of liquid-fueled silo-based and solid-fueled road-mobile platforms, the PLARF is clearly moving toward a solid-fueled, road-mobile, and multiple independently targetable reentry vehicle (MIRV) capable system. Due to the requirement of its minimum deterrence strategy, only a small number of systems need to survive a first strike to retaliate. However, as launch detection and missile defense technologies continue to mature, confidence in the reliability of assured retaliation has subsided. The solution could be to invest in a combination of newer platforms such as the MIRV-capable, DF-31A/CSS-10 Mod-2, DF-41/CSS-X-10 and dual-capable hypersonic glide vehicle (HGVs) Wu-14/DZ-ZF, which would allow the PRC to remain confident with its smaller number of nuclear assets.

The employment of HGVs would alter the perception of a strategic shortcoming between the United States' BMD and the PLARF's penetration capability. Perhaps, the PLARF intends to mirror the utility of its HGVs in a similar fashion to how they believe the United States would use its PGS.[40] The circumstances under which HGVs could be used and the perceived nature of its payload (nuclear or

35. Mark Stokes, *China's Nuclear Warhead Storage and Handling System* (Washington DC: Project 2049, 2010), https://project2049.net/2010/03/12/chinas-nuclear-warhead-storage-and-handling-system/.
36. Department of Defense, *Annual Report to Congress* (Washington DC, Department of Defense, 2018), 75.
37. Defense Intelligence Agency, *China Military Power Modernizing A Force to Fight And Win*, (Washington DC: Defense Intelligence Agency, 2019), 33.
38. Hans Kristensen, "Air Force Briefing Shows Nuclear Modernizations But Ignores US and UK Program," Federation of American Scientists, May 29, 2013, https://fas.org/blogs/security/2013/05/afgsc-brief2013/.
39. Panda, "Revealed: China's Nuclear Capable Air-Launched Ballistic Missile."
40. Lora Saalman, *Factoring Russia into the US-Chinese Equation on Hypersonic Glide Vehicles* (Solna, Sweden: SIPRI, 2017), 8, https://www.sipri.org/publications/2017/sipri-insights-peace-and-security/factoring-russia-us-chinese-equation-hypersonic-glide-vehicles.

conventional) could carry significant risk to the stability of nuclear deterrence.[41] If its application is of a conventional nature, then its likelihood of use would increase. If the payload is nuclear, then the fielding of such a platform would lead the PRC to believe that it could achieve some degree of parity with the United States despite the numerically inferior arsenal. However, by the same logic that prompted the PRC to develop HGV technology, the United States would further enhance the sophistication of its BMD system to counter such a threat. This, in turn, would prompt the PRC to develop a countermeasure, thus perpetuating the endless conundrum of sword and shield. The race for hypersonic supremacy could result in a costly and destabilizing global arms race.

THE PEOPLE'S LIBERATION ARMY STRATEGIC SUPPORT FORCE

Another area where the implementation of new technologies could generate the greatest impact in the nuclear realm is the PLA's counter-space capabilities such as direct ascent antisatellite (ASAT), co-orbital ASAT, direct energy, and cyber weapons.[42] When the PLASSF was created in 2015, General Gao Jin, the former chief of staff of the Second Artillery Corps (the predecessor to the PLARF), was selected as the new service's first commander.[43] Due to General Gao's experience, space-based, cyber, and electronic warfare capabilities could play a larger role in the PLA's future nuclear thinking, deterrence, and escalation control operations. Overall, the PLASSF will become the key driver in developing technologies and tactics that target the United States' operational reliance on the flow of information from its space-based architecture. Especially for the nuclear realm, the PLA's counter-space capabilities would allow its nuclear force to address the penetration weaknesses in regard to the United States' BMD through its counter-space capabilities. Additionally, the potential adoption of a LOW posture could very well depend on the PLASSF's network of sensors and its early warning ability. However, the proliferation and reliance on dual-use technologies in space would place a premium on its space-based assets and increase the potential for hostile activity. This dynamic could serve as a pathway toward inadvertent escalation due to a misconstruing of intention during a limited conflict.[44]

THE FOURTH TAIWAN STRAT CRISIS

FUTURE OF THE NFU

Even though the PLA's retaliatory capability could serve as a deterrent against a nuclear strike upon the Chinese mainland, it is not clear whether the CCP believes that its arsenal is sufficient to deter escalation in the conventional realm.[45] It is in Beijing's interest to maintain the public façade of strict adherence to its NFU policy. As long as the PRC can preserve the belief of the survivability and penetration capability of its nuclear forces, it could reduce the advantage of other states with larger quantities. Perhaps this is the main motivation behind the PRC's push toward a nuclear triad. If the CCP can create the sort of arsenal needed to bolster its nuclear confidence in peacetime, then it could stand a greater chance at escalation control during a conflict. Under the premise that a robust PRC nuclear arsenal could deter the use of the United States' nuclear weapons as a coercive

41. Saalman, "Prompt Global Strike: China and The Spear," 14.
42. Tate Nurkin et al, *China's Advanced Weapons Systems* (Jane's by IHS Markit, 2018), 140, https://www.uscc.gov/sites/default/files/Research/Jane%27s%20by%20IHS%20Markit_China%27s%20Advanced%20Weapons%20Systems.pdf.
43. Rachel Burton, *The People's Liberation Army Strategic Support Force: Leadership and Structure* (Washington DC: Project 2049, 2018), https://project2049.net/wp-content/uploads/2018/09/180925_PLA_SSF_Leadership-and-Structure_Stokes_Burton.pdf.
44. James Acton, "Inadvertent Escalation and the Entanglement of Nuclear Command-and Control Capabilities," *International Security* 43, no. 1 (Summer, 2018), 56-99, 72.
45. Liu Ching, "The Relationship Between Nuclear Weapons and Conventional Military Conflicts," in *Understanding Chinese Nuclear Thinking*, ed. Li Bin and Tong Zhao (Washington DC: Carnegie Endowment for International Peace, 2016), 157.

or warfighting tool, any future conflict would depend on the PLA's conventional capability. Even if the United States chose to intervene in a Taiwan scenario, neither side would have strong incentives to threaten the use of nuclear weapons early in the conflict. However, as the conflict continued, the fear of uncertainty and dramatic losses would test Beijing's resolve to adhere to its NFU policy. According to the *China Strategic Missile Force Encyclopedia*, there are four pathways toward nuclear escalation for a nuclear-powered state who is engaging in a regional conflict:

- An extremely serious international crisis could take place, and a nuclear imbalance between the countries involved would lead one side or the other to believe that a nuclear first strike would allow it to seize the initiative or accomplish its strategic objectives.[46]
- Conventional war could escalate to the nuclear level because "a hegemonic nation that possesses nuclear weapons" is losing a conventional war and concludes that it must "use nuclear weapons to reverse the situation" or because a country that does not have a NFU policy believes its national survival is at stake and resorts to nuclear escalation.[47]
- "Political errors" could lead to nuclear war because "the enemy makes an erroneous strategic judgement on certain actions and takes drastic actions that cause the situation to go out of control and leaders to declare nuclear war."[48]
- "Accidental nuclear war" could take place when, as a result of command and control errors or malfunctioning weapons systems, "one country mistakenly launches nuclear missiles on the territory of another country."[49]

If the PLA certainly believes in these dynamics, is it counterintuitive for it to remain ambiguous over the conditions in which its NFU policy would apply? Several likely caveats for the PLA to supplement its declaratory policy are:

- An enemy is threatening to carry out conventional strikes against China's nuclear facilities or nuclear power stations.[50]
- An enemy is threatening to carry out attacks against major strategic targets, such as hydroelectric power stations.[51]
- An enemy is threatening to carry out attacks against the capital, major cities, or other political or economic centers.[52]
- The PRC is facing serious danger or impending disaster because it is losing a conventional military conflict in which the stakes are very high.[53]

These clarifications on the ambiguous conditions of the NFU policy do not equate to a deliberate attempt to lower the threshold of nuclear use. The emphasis of such an act would be on applying additional constraints on U.S. planners in selecting potential targets and on imposing further psychological pressure on the decisionmaking processes of American decisionmakers. While there

46. *中国战略导弹部队百科全书*, *China Strategic Missile Force Encyclopedia*, (Beijing, People's Republic of China: China Encyclopedia Publishing House, 2012), 3.
47. Ibid.
48. Ibid.
49. Ibid.
50. Yu Jixun, *第二炮兵战役学*, *Science of Second Artillery Campaign*, (Beijing, People's Republic of China: People's Liberation Army Press, 2004), 294-295.
51. Ibid.
52. Ibid.
53. Ibid.

is little evidence to conclude that the PRC would publicly augment or even abandon the NFU policy in the near future, the temptation and the opportunity to revamp its strategy will always be present. This is especially true in an instance such as a botched attempt to invade Taiwan, which could leave the CCP in a politically and military untenable situation. In these scenarios, Beijing might accept far more risk than expected.

POSSIBLE ESCALATION PATHWAYS

While there are many variables that go into the CCP's decision on how to pursue unification with Taiwan, the ability to deter U.S. intervention, resists its coercions, and the PLA's conventional superiority against Taiwan are key factors. In a conflict where an asymmetry of power exists, the stronger side would seek to prevent the conventional conflict from turning nuclear. On the other hand, conventional wisdom indicates that the weaker side would seek to muddle the line between the nuclear and conventional realms to inhibit the breakout of such conflict. However, due to the limited utility of its nuclear arsenals, the PRC would also establish a solid firebreak between the two realms. Therefore, making a perceived limited conflict in the air and maritime domains such as one in the Taiwan Strait somewhat innocuous due to either sides' impressions that they could prevent further escalation. Under this logic, if Beijing believes it could maintain strategic deterrence with the United States, it would be able to exploit the stability-instability paradox to subdue Taiwan before Washington could mobilize the bulk of its forces in the Western Pacific.

If conventional capability is a deciding factor, the PLA is not lagging far behind. As opposed to the United States' approach of total domination in all spectrums of combat, the PLA has chosen to concentrate its resources on several strategic "trump cards" to exploit U.S. psychological and physical weaknesses. Platforms that provide precision strike capability such as intermediate-range anti-ship ballistic missile (ASBM) platforms, including the DF-21D/CSS-5 Mod-4 and the DF-26, are designed with a specific target in mind: U.S. Navy aircraft carriers.[54] As a proven combat platform and an enabler of the United States' power projection, the ability to keep an aircraft carrier battle group at a distance would make the invasion of Taiwan a bit less costly and further complicate the risk-acceptance matrix of U.S. decisionmakers. Nevertheless, the reliability and the overall quality of the PLA are untested in combat. Short of a sudden declaration of independence from Taipei or drastic economic and political downturns, Beijing should not be compelled to venture down the route of an overt conflict. Doing so would place the PLA at a distinct disadvantage to the conventional capabilities of the United States and its robust network of partners in the region.

In the event of a total failure of deterrence in the Strait, the conflict between the United States and the PRC would commence far below the nuclear threshold. Both sides would rely on their conventional capabilities to achieve their military and political objectives. Nevertheless, there would be incentive to take the initiative in lesser escalatory domains such as cyber and space. Because the incentives for deliberate use of nuclear weapons at the early stage are quite low, this belief would create a false sense of conflict stability within the military planners and political leaders in Beijing and Washington. Emboldened by this sensation of high controllability, each side would have the relative freedom to pursue its military objectives as quickly as possible to minimize the losses of manpower and national resources. However, as the conflict drags on and loss aversion starts to permeate throughout both capitals, what started out as limited maritime conflict would find itself

54. Otto Kreisher, "China's Carrier Killer: Threat and Theatrics," *Air Force Magazine*, December 13, 2013, http://www.airforcemag.com/MagazineArchive/Pages/2013/December%202013/1213china.aspx.

reaching higher rungs of the escalation ladder. These are some of the possible routes toward the introduction of nuclear weapons in the Taiwan Strait:

- One side perceives that the conventional conflict is going badly for them and there is little chance that it could achieve its military objectives. In that moment, that side could threaten nuclear escalation to place pressure on the other side to salvage a political victory.[55]
- Attempts to neutralize a space-based asset to achieve a conventional objective could be misconstrued as a preparation for a nuclear strike by the other side, which would prompt the defender to overact by lowering the threshold of nuclear use.[56]
- Accidental destruction of the PRC's strategic assets such as its SSBNs or the PLA-entangled command-and-control network due to the fog of war and the speed of conflict could create a strong "use it or lose it" situation.[57]

Perhaps, the preferred option would be a series of extensive information campaigns that target both the decisionmakers and the general population of the United States, as well as those of Taiwan. To achieve its objective, the PRC could turn toward coercive measures to further isolate the government of Taipei from Washington. To muddle U.S. resolve, the PRC could leverage the asymmetrical level of interests and engage in the manipulation of risk to target the U.S. public's intolerance for losses of lives, resources, and the general aversion to conflict.[58] In this scenario, Beijing could lean on the perceived lethality of its precision strike, cyber, and counter-space capabilities against U.S. assets to impose cost. Additionally, the PRC could frame the argument that a U.S.-led intervention has the potential to inadvertently escalate into the nuclear realm. The ambiguity in what the PRC deems appropriate for nuclear retaliation would become an important factor in this situation. By adopting an asymmetrical approach in the Taiwan Strait, the PRC could influence its advantages to compel a risk-averse enemy to back down or incur the unnecessary cost of defending a reputational interest. After all, Sun Tzu dictated: "To fight and conquer in all our battles is not supreme excellence; supreme excellence consists in breaking the enemy's resistance without fighting," and the CCP is adept at concealing its real intention through strategic disinformation.[59]

CONCLUSION

As the PLA's integrated strategic deterrence capabilities continue to grow, the Taiwan dilemma will continue to evolve into one of the most dangerous flash points between the United States and the PRC. For the United States, its prior challenges of simultaneously maintaining deterrence and assurance in the Strait were very different from those of today. Vice versa, this current PRC is no longer its former restrained self. Along with its economic ascension has come a renewed set of expectations and desires. While it is preposterous to believe that the United States could simply surrender its interests in preserving the status quo without damaging the perception of its commitment worldwide, it is also in its interest to recognize the differences between the escalation dynamics and crisis stability of the past versus those of the future. To assume that the next crisis in the Taiwan Strait could be managed by turning to previous measures would be a colossal miscalculation.

55. Fiona Cunningham, "Great Power Escalation" (presented at the Georgetown University Conference on The Theory and Practice of Nuclear Weapons and International Security, Washington DC, March 19, 2019).
56. James Acton, "Escalation through entanglement," 58.
57. Caitlin Talmadge, "Would China Go Nuclear?" *International Security* 41, no.4 (Spring, 2017): 50-92, 55.
58. Robert Kagan, "America's Dangerous Aversion to Conflict," The Brooking Institution, September 5, 2014, https://www.brookings.edu/opinions/americas-dangerous-aversion-to-conflict/.
59. Sun Tzu and Samuel B. Griffith, *The Art of War*, (Oxford, United Kingdom: Oxford University Press, 1963).

An Offensive Leap

An Analogy of Hypersonic Weapons to Early ICBMs

Kyle Yohe[1]

ABSTRACT

Hypersonic weapons pose a great leap in offensive standoff capability, the likes of which has not been seen since the introduction of the first Intercontinental Ballistic Missiles (ICBMs). Traveling at speeds above Mach 5, hypersonic weapons are highly maneuverable, evading detection and out-speeding defenses. A country may be capable of identifying the launch of a hypersonic weapon, but it will be unable to ascertain its target and whether it carries a nuclear payload. This ultimately will increase the risk of nuclear confrontation due to miscalculation. The last time the world faced a new credible strategic threat like this was immediately following the creation of ICBMs, when counterforce capability was underdeveloped, and missile defense was not yet technically achievable. This paper seeks to analyze the impact of emerging hypersonic weapons on global strategic stability and uses a historical case study of ICBMs to identify, manage, and address the strategic implications of this new weapons technology.

INTRODUCTION

It is often stated in the nuclear security policy realm that the only justified use of a nuclear weapon is an in-kind retaliation to a previous nuclear attack. Yet, as conventional weapons technology progresses, there will exist a subset of weapons that are categorically conventional but of such a strategic magnitude to also warrant a nuclear response. The strategic implications of space and cyber are often discussed, but there is a much more limited discussion on the impact of hypersonic weapon technology. Near term, hypersonic weapons will pose a significant threat to the current strategic balance of power and operations of great power nations.

Hypersonic weapons have a combination of speed, maneuverability, and reach that is unmatched by any current weapon system while being nearly impossible to defend against with present

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capabilities. These assets drastically shorten the kill chain timeline from launch assessment to weapons impacts. This kill chain timeline outpaces current nuclear command and control capabilities, thus threatening the ability of the United States to employ nuclear weapons. These weapons have the potential to increase the risk of entanglement, increase the risk of rapid conflict escalation or nuclear miscalculation, and lead to an overall degradation in the global security balance.[2]

The United States must develop its own hypersonic weapons in order to hedge other nations' advancements in strategic deterrence through hypersonics. It will also allow the United States to match the conventional strike timeline of any adversary nation. As well as matching the offensive capability, the United States must also overhaul its NC3 system. The United States needs a modern system that prioritizes speed and redundancy, which will be necessary to compete in a world of shortened strike timelines. Where minutes and hours were the measurement units of the past, the systems of the future must operate in domains measured by seconds and microseconds.

HYPERSONIC TECHNOLOGY

To date, the United States, Russia, and China have reportedly successfully tested maneuverable hypersonic vehicles, and other nations are actively aspiring to join this club. To be considered hypersonic, an object must travel at Mach 5, or five times the speed of sound (3,836 mph).[3] Many objects (and even humans) have traveled at these speeds, but most were ballistic objects accelerated by gravity as they reentered the earth's atmosphere. The hypersonic weapons considered in this paper are the Hypersonic Glide Vehicle (HGV) and the Hypersonic Cruise Missile (HCM). HGVs are unpowered vehicles launched ballistically into the upper atmosphere by rockets, where they then maneuver to their targets at hypersonic speeds. HCMs are launched from aircraft or submarines and are powered to their targets by rockets or advanced jet engines, such as supersonic combustion ramjets (scramjets). While capable of carrying conventional or nuclear payloads, due to the speed of these weapons, an explosive warhead is not required; RAND research indicates that a Mach 8, 500 kg hypersonic vehicle would have the destructive power equivalent to 3.25 tons of TNT with only kinetic energy and no explosive payload.[4]

In 2018, during the presidential address to the Federal Assembly, Russian president Vladimir Putin unveiled several weapons that are in development to advance the Russian nuclear strategy. This included both an HGV and an HCM. Putin's reported assessment of the Avangard HGV showed that it is capable of intercontinental flight at speeds over Mach 20. The Kinzhal HCM was described as having a range of 2,000 km and maneuvering at speeds of Mach 10. Both weapons are reportedly capable of conventional and nuclear payloads.[5] China has successfully tested the XingKong-2 HGV, which has achieved sustained hypersonic flight for over 400 seconds.[6] To date, China contends that hypersonic testing is an advancement of its space program and has not made claims to weaponizing the technology.[7]

2. James M. Acton, *Silver Bullet?: Asking the Right Questions about Conventional Prompt Global Strike* (Washington DC: Carnegie Endowment for International Peace, 2013).
3. Eric Limer, "How Fast Is Hypersonic Speed, Really?" *Popular Mechanics*, September 28, 2017, https://www.popularmechanics.com/flight/a28426/hypersonic-speed-math-examples/.
4. Richard H. Speier, George Nacouzi, Carrie Lee, and Richard M. Moore, *Hypersonic Missile Nonproliferation: Hindering the Spread of a New Class of Weapons* (Santa Monica, CA: RAND Corporation, 2017), 13.
5. Vladimir Putin, "Presidential Address to the Federal Assembly" (address, Manezh Central Exhibition Hall, Moscow, Russia, March 1, 2018).
6. "Xingkong-2/Starry Sky 2," GlobalSecurity.org, September 19, 2019, https://www.globalsecurity.org/wmd/world/china/xing-kong-2.htm.
7. John Grady, "Panel: China Leading the World in Hypersonic Weapon Development," U.S. Naval Institute, March 14, 2019,

Countries pursue hypersonic technology for many reasons; however, one reason that cannot be overstated is the potential these weapons bring to bypass traditional missile defense. The overarching opinion is that current-generation surface-to-air missile defense and ballistic missile defense weaponry is entirely incapable of intercepting a hypersonic missile or glide vehicle.[8] Today's strategic ballistic missiles, although incredibly fast, travel at predictable, ballistic trajectories. Ballistic trajectories serve as the backbone of all missile defense: if the missile can be detected, its path can be projected, and it can be intercepted. Additionally, today's cruise missiles are subject to surface-to-air missile threats. Next-generation, maneuverable hypersonic weapons do not follow these constructs. They fly lower and change directions at extremely high speeds. As a result, the flight path cannot be projected because the weapon possesses the capability to change its flight path.

COMMAND AND CONTROL IN A TIME CONSTRAINED ERA

The U.S. nuclear posture seeks to ensure that the president (or a lawful successor) has the capability and time to issue nuclear response options to the forces. The Nuclear Threat Initiative estimates that a Russian ICBM would take 25 minutes from launch until impact. The U.S. satellites would detect launch within one minute, and within four minutes, NORAD would alert the White House. The president would be briefed on the matter within an additional five minutes. From the time the president is alerted, he would have six minutes to reach his advisers, get briefed on the strategic assessment, query his advisers, and select a response option. After two minutes of transmitting the order, this allows for 10 minutes for the messages to reach an ICBM nuclear launch officer and for them to execute the order.[9]

Hypersonic weapons have the means to alter the current nuclear command, control, and communications (NC3) construct and decision timeline. RAND estimates that ground-based sensors could detect and track a 3,000 km range ballistic reentry vehicle 12 minutes prior to impact, while an HGV would only be detected six minutes prior to impact.[10] An HCM would be harder to detect due to its lack of ballistic launch and its ability to be launched closer to a target. An HCM launched 1,000 km from the United States would shorten response time from twelve to six minutes.[11] Even with an effective launch warning, it would be highly unlikely to ascertain the target of an HGV/HCM due to its ability to maneuver.

A decreased assessment to impact timeline would thus necessitate an altered NC3 structure. This shortened command and control timeline could occur with more accurate threat assessment capabilities, semiautonomous/autonomous analysis, and faster response communications. However, moving to semi-autonomous/autonomous analysis raises many potential issues—including the impact of false positives, risk of cyber exploitation, and rapid conflict escalation—that are outside the scope of this research. Even with a complete overhaul of the current NC3 system, it is hard to imagine executing a nuclear response option within six minutes of strategic warning. Thus, other options include the delegation of nuclear response or more aggressive nuclear launch posturing. Each of these options would increase the likelihood of an incorrect or errant nuclear execution order.

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https://news.usni.org/2019/03/14/panel-china-leading-world-hypersonic-weapon-development.

8. "Hypersonic weapons: can anyone stop them?" Air Force Technology, October 16, 2018, https://www.airforce-technology.com/features/hypersonic-weapons-can-anyone-stop/.
9. Jeffrey Lewis, "Is Launch Under Attack Feasible?" Nuclear Threat Initiative, August 24, 2017, https://www.nti.org/analysis/articles/launch-under-attack-feasible/.
10. Speier et al., *Hypersonic Missile Nonproliferation*, 11.
11. Ibid., 17.

Without the capability to beat the hypersonic strike timeline, the NC3 system is at risk of a decapitation strike. The current system in which the president maintains sole nuclear command authority creates increased risk that a preemptive hypersonic strike could cause significant delays to or prevent the execution of a nuclear response. It also raises the possibility that a hypersonic weapon could strike strategic communication nodes in the NC3 system, preventing the president from communicating a nuclear response to the nuclear forces. This delay would negate the capabilities of the nuclear triad; nuclear capabilities would not need to be destroyed if they can be cut off from the sole execution authority.

HISTORICAL APPLICATION OF THE EMERGENCE OF ICBMS

The advent of hypersonic weapons, while new and unique, is not without historical precedent and significance. To be sure, the capabilities that HGVs and HCMs possess—mainly increased maneuverability and unmatched speed—will change the application of offensive and defensive military strategy. These new capabilities will make most—if not all—modern missile defenses obsolete and thus may usher in an era of offensive superiority. Without a defensive capability, hypersonic weapons capability can give a nation an outsized impact. Yet this new era is not wholly unfamiliar; it is a modern reincarnation of the dawn of the ICBM era. Thus, a historical case study of the strategic impact of ICBMs serves as a foundation to address the modern impact of hypersonic weapons in the global strategic landscape.

With the introduction of the ICBM, a nation could hold another nation at great risk of large-scale strategic destruction. The ICBM provided emerging capabilities that could not be matched with a strategic bomber force. An ICBM could be launched on a drastically shortened timeline across great distances. Anti-aircraft artillery and surface-to-air missiles, while an effective match against a nuclear bomber force, were no match against a ballistic missile. With a heightened offensive focus, the Cold War arms race began with the Soviet Union and the United States building up large arsenals of strategic intercontinental weapons. The prevailing strategies of the times were offensively minded—mutual assured destruction, launch on warning, and effective second strike. Simply stated, deterrence could only occur by projecting the capability and will to inflict extreme costs on an enemy.

The U.S. advantage in ICBM technology was quickly minimized by the Soviet Union. In the early 1980s, the Soviet Union was predicted to hold an upwards of 90 percent of U.S. ICBM forces at risk: *"heightened awareness of this potential vulnerability has been an important factor in the perception of declining American strategic power, in the rhetorical opening of the 'window of vulnerability,' and in the demise of SALT II."*[12]

The emerging Soviet offensive ICBM capability raised the question of the survivability of the U.S. ICBM force. A survivable ICBM force was critical because it discouraged the Soviets from executing a first strike because the United States could always have a second-strike capability. It also provided the United States a strategic hedge against degradation, limitations, and potential decreased readiness or posturing of the other components of the nuclear triad.[13] The main proposals to counter this offensive threat to U.S. ICBMs could be lumped into five categories: "arms control, launch-under-attack, hardening, preserving locational uncertainty, and active defense."[14]

12. Albert Carnesale and Charles Glaser, "ICBM Vulnerability: The Cures Are Worse Than the Disease," *International Security* 7, no. 1 (1982): 70.
13. Ibid., 71.
14. Carnesale and Glaser, "ICBM Vulnerability," 71.

The offensive-minded vision was threatened after President Ronald Reagan's "Star Wars" speech on March 23, 1983. At the moral level, President Reagan felt "the human spirit must be capable of rising above dealing with other nations and human beings by threatening their existence." His ultimate vision was a defense that "render[ed] these nuclear weapons impotent and obsolete." In Reagan's view, his ideal Strategic Defense Initiative (SDI) held "the promise of changing the course of human history."[15] Multiple reports were commissioned to analyze the proposed SDI; the most optimistic recognized that a multilevel approach could theoretically reach 99 percent effectiveness in the coming decades. If technically feasible, this would still allow leakage of around 300 reentry vehicles to reach their targets.[16] As the success rate of a defense declines, the importance of unmatched offensive capability is further heightened both in its pure offensive capability as well as its deterrent effect. As Donald Hafner wrote, "deterrence based on retaliatory weapons is a difficult condition to escape in a nuclear world."[17]

Yet, decades and billions of dollars later, the United States is nowhere near Reagan's vision of a perfect defense that has rendered nuclear weapons obsolete. It seems that every president since has had missile defense programs that continued to fall short: Reagan had SDI, George H. W. Bush had Global Protection Against Limited Strikes (GPALS), Bill Clinton had National Missile Defense (NMD), and George W. Bush had Ground-based Midcourse Defense (GMD). Our current missile defense posture includes 44 GMD interceptors for national defense as well as Aegis, THAAD, and Patriot systems for limited theater and point defense.[18] Even against targets with known ballistic trajectories, the successful operation of these systems is a technological feat and has been colloquially described as "hitting a bullet with a bullet." Due to the limited number of GMD interceptors, the United States would be unable to defend the homeland against the full strategic might of Russia. GMD is most suitable to defend against a limited strike such as a ballistic threat from North Korea. In a period of constrained budgets and many competing domestic policy agendas, allocating spending for ballistic missile defense is a tough political sell. The topic of ballistic missile defense is unlikely to top the list of concerns amongst voters and thus will be unlikely to make it onto a congressional member's already busy schedule. In this way, many generations of work and spending have led to the current numerically limited national defense.

In an era of near nuclear parity between strategic nations, as the idea of perfect defense to ICBMs has been shown to be both politically, technologically, and economically unfeasible, the next change in the global strategic landscape will surely be offensive. ICBMs brought about a technological leap in speed, readiness, and survivability; this capability altered the deterrence calculus of nuclear nations. Hypersonic weapons pose the next leap forward in altering the strategic thought of great power nations. In the six decades since the first ballistic missile launch, ballistic missile defense is only executable in a technologically and numerically limited fashion. It appears reasonable to assume that hypersonic defense will take significant funding and years of research.

15. Ronald Reagan, "Address to the Nation on Defense and National Security," March 23, 1983, https://www.reaganlibrary.gov/research/speeches/32383d.
16. Donald L. Hafner, "Assessing the President's Vision: The Fletcher, Miller, and Hoffman Panels," *Daedalus* 114, no. 2 (1985): 98.
17. Ibid., 100.
18. Kingston Reif, "U.S. Missile Defense Programs at a Glance," The Arms Control Association, January 2019, https://armscontrol.org/factsheets/usmissiledefense.

STRATEGIC IMPLICATIONS OF HYPERSONIC WEAPONS

Although hypersonic weapons and ICBMs are similar in that during their emergence they were both considered to be indefensible, it is also worth highlighting the differences. These, too, must be considered if there is anything the United States can learn about the effects these weapons will have on deterrence policy. The heightened reliance on dual-use assets, the evolution of Russian thinking on nuclear use, and the proliferation of nuclear weapons are relevant when studying the differences between hypersonic weapons and ICBMs.

The term entanglement is attributed to John Steinbruner, who used it to describe the risks of a nonnuclear war turning nuclear.[19] The premise is that the nuclear enterprise relies on various capabilities that support both nuclear and conventional missions. An attack on those capabilities in order to degrade a nation's conventional warfighting capability will also inherently function as an attack on a nation's nuclear ability. Ultimately, a country that feels that its nuclear capability is compromised or can be destroyed will be more likely to respond in a nuclear fashion.

Another interesting wrinkle in the study of entanglement is what happens when nuclear assets can be held at risk by nonnuclear weapons. In the early stages of ICBM development, strategic nuclear weapons were the only thing holding adversary strategic nuclear weapons at risk. With the development of high-precision hypersonic weapons, it is realistic to think that many nuclear assets could be held at risk even with conventional weapons. With their range and high speeds, hypersonic weapons could plausibly bring enough kinetic energy upon targets that previously only nuclear weapons could defeat.

For the greater part of the last two decades, the United States has considered hypersonics under the umbrella of the Prompt Global Strike (PGS) programs. Reports indicate that nonnuclear hypersonic weapons could hold at risk up to 30 percent of targets that are currently considered to require a nuclear weapon.[20] While this may appear to lead to an overall reduction of the likelihood of nuclear weapon use, it also lends itself to scenarios in which nonnuclear attacks generate a nuclear response. The further development and deployment of hypersonic weapons will only contribute to this imbalance of proportional response.

As discussed earlier, mutually assured destruction was one of the prevailing strategies during the ICBM era. Any nuclear use was sure to be met with an in-kind nuclear response. However, there exists today altogether different nuclear doctrines that are less clear. Most notable to this research paper is Russia's potential strategy of "Escalate to De-escalate." The concept of escalate to de-escalate is that Russia will increase its number of geopolitical actions that signal its willingness to engage in select preemptive nuclear strikes in order to more quickly resolve conflicts.[21]

If the United States is to believe in the Russian use of this escalation management strategy, the ways how the development of hypersonic weapons act as an enabler must also be considered. If Russia can execute indefensible, limited nuclear strikes anywhere in the world through the use of a hypersonic weapon, it could project power in a way that it cannot right now. It would provide a significant

19. James Acton, "Why Is Nuclear Entanglement So Dangerous?" Carnegie Endowment for International Peace, January 23, 2019, https://carnegieendowment.org/2019/01/23/why-is-nuclear-entanglement-so-dangerous-pub-78136.
20. Hans Kristensen, "Talks at U.S. Strategic Command and University of California San Diego," Federation of American Scientists, August 12, 2012, https://fas.org/blogs/security/2012/08/talks/.
21. Mark Schneider, "Escalate to De-escalate," U.S. Naval Institute, February 2017, https://www.usni.org/magazines/proceedings/2017/february/escalate-de-escalate.

increase in Russian power projection and the ability to counter the unmatched U.S. conventional capability. This would critically weaken U.S. ability to control security interests abroad. The United States needs to strongly consider Russia's resolve to "de-escalate" a conflict through the use of a limited nuclear strike and how hypersonic weapons will give it yet another tool to do so without fear of interception.

When considering the differences between hypersonic weapons and ICBMs, it is worth looking at the landscape of strategic weaponry. The first ICBMs were deployed operationally in 1959 by both the United States (Atlas) and the Soviet Union (R-7A). At the time only the United States, United Kingdom, and Russia had successfully tested and produced nuclear weapons. France and China followed in the 1960s with India, Pakistan, and North Korea developing nuclear weapons in the following decades.[22] The relatively small number of nuclear weapons states is primarily due to the treaties and nonproliferation agreements that have been made and generally globally agreed upon.

Hypersonic technologies do not have the same proliferation restrictions that limit nuclear weapons. Considering the lack of restriction on nonnuclear hypersonic weapons development, there may be a parallel emergence of a hypersonic weapons market. In principle, this could allow nonnuclear states to check nuclear states with these new capabilities. In this case, the proliferation of this technology could weaken the ability of the United States to deter conflict.

CONCERNS WITH HYPERSONIC ARMS CONTROL

A hypersonic weapons arms control agreement could work well to limit the development, production, stockpiling, proliferation, and usage of hypersonic weapons. The United Nations Office for Disarmament Affairs and the United Nations Institute for Disarmament Research jointly produced a document in February 2019 detailing a possible arms control solution to limit the use of hypersonic weapons. The main concerns outlined in the study relate to political mistrust of potential signatories. There is also a firm belief by China and Russia that hypersonic weapons are absolutely necessary to domestic defense. Other concerns have to do with verification and protecting classified technologies.[23]

If the United States wishes to restrict the development of hypersonic weapons, it could actively solicit participation from Russia and China through bilateral or multilateral agreements. The spectrum of what is possible spans from nonproliferation agreements to flight test bans. Any written agreements could be verified through inspections, continuous monitoring systems, facilities declarations, or even regular data exchanges.

Arms control becomes difficult in this case because of two factors: political mistrust and the belief that hypersonic technologies are vital to national defense. During the Intermediate-Range Nuclear Forces (INF) Treaty renegotiations, both Russia and the United States claimed that the other had violated the treaty. This only leads to a belief that ratified treaty language is not completely binding and thus not all that useful. The United States has to consider what aspects of arms control negotiations are ineffective and address whether it wishes to control hypersonic weapons.

22. Hans Kristensen and Robert Norris, "Status of World Nuclear Forces," Federation of American Scientists, November 2018, https://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/.
23. John Borrie, Amy Dowler, and Pavel Podvig, "Hypersonic Weapons: A Challenge and Opportunity for Strategic Arms Control," United Nations Office for Disarmament Affairs and United Nations Institute for Disarmament Research, February 2019, https://www.un.org/disarmament/publications/more/hypersonic-weapons-a-challenge-and-opportunity-for-strategic-arms-control/.

Alternatively, a nation is unlikely to limit development of a technology if it feels like the specific technology is necessary to its defense. A perfect example of this is North Korea's withdrawal of the Treaty of the Non-Proliferation of Nuclear Weapons (NPT). In 2003, North Korea's perceived need to pursue nuclear weapons for its survival outweighed the benefits of being an NPT signatory. In 2018, Russian president Vladimir Putin used similar rhetoric when describing the need to acquire hypersonic weapons:

> [T]he US, is permitting constant, uncontrolled growth of the number of anti-ballistic missiles, improving their quality, and creating new missile launching areas. If we do not do something, eventually this will result in the complete devaluation of Russia's nuclear potential. Meaning that all of our missiles could simply be intercepted.[24]

This rationale attempts to place the blame on the United States and rationalize new strategic weapons development. Ultimately, Putin is seeking new ways to counter the United States' unmatched conventional capabilities. It seems unlikely that Russia would sign an agreement to limit its hypersonic development when it sees that capability as necessary for upholding Russia's nuclear response option.

CONCLUSION

The historical case study on the emergence of ICBMs sheds light on how new technologies alter the global strategic balance of power. The ICBM shifted global strategic powers from an offensive-defensive development cycle to an offensive-offensive cycle. Without effective defensive capabilities, the only method to counter an enemy's offensive ICBM capability was for a nation to develop its own increasingly capable ICBMs. From the advent of the ICBM, the prevailing global security strategies have focused on displaying/threatening capabilities that incur the greatest costs to the enemy in order to alter decision making. For deterrence to work, nations must have both the offensive capability and the will to use it.

The story of ICBMs indicates that the first mover and capabilities leader in unmatched offensive weaponry can reshape the global balance of power. Learning from ICBMs, the choice exists between arms control measures and arms races. Hypersonic weapons create a risk of upending the current global balance of power because they can threaten a "decapitation" strike or hold U.S. nuclear targets at risk. The United States must develop its own hypersonic capabilities to match the shortened strike timelines of other nations. Due to the limited defensive capabilities against hypersonic weapons, the United States must drastically modernize its NC3 system to account for shortened timelines. The president (or lawful successor) will always make the nuclear decision, so the United States must drastically shorten all other aspects of the response chain-of-events. It must seek to increase the redundancy and speed of threat detection, warning, and categorization through increased automation or potential use of artificial intelligence. The United States must also increase the redundancy of its communication networks to decrease the likelihood of a "decapitation" strike. The development of hypersonic weapons is the modern iteration of an unmatched offensive capability.

24. Putin, "Presidential Address to the Federal Assembly."

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