

DECEMBER 2025

On the Horizon

A Collection of Papers from the Next Generation

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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 creative opportunities for rising experts to learn about policy, technical, and operational aspects of the nuclear community, develop and present new concepts and ideas, engage in thoughtful and informed debates, and tour and visit sites across the nuclear enterprise.

PONI strives to achieve this mission through several objectives, including:

- 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;
- Providing a networked platform for information sharing and collaboration across the nuclear community; and
- 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.

Among the various programming opportunities available through PONI, the authors in this publication were members of PONI's 2025 Nuclear Scholars class. The PONI Nuclear Scholars Initiative is a group of select graduate students and young professionals. The initiative aims to provide top graduate students and young professionals from around the country with a unique venue to interact and hold dialogue with senior experts on nuclear weapons issues. Those accepted into the program are hosted monthly at CSIS in Washington, D.C., where they participate in day-long

workshops with senior government officials and policy and technical experts. Over the course of the six-month program, PONI Nuclear Scholars are required to prepare a written product. PONI has several alumni from this initiative, many of whom continue to work in the nuclear field and play key roles in nuclear policy development, technical innovations, and operations.

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PONI extends its thanks to the authors for their dedication throughout the research and writing process and for their outstanding products. We appreciate our senior experts and Mid-Career Cadre members who reviewed and edited the chapters, provided mentorship and guidance, and spoke with the Nuclear Scholars during their workshops. PONI could not function without their generosity and support. The editor also received tremendous support with proofreading and feedback from their colleagues at PONI, including Diya Ashtakala, Lachlan MacKenzie, Nicholas Adamopoulos, Joseph Rodgers, and Heather Williams.

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Introduction

By Doreen Horschig

The nuclear environment continues to shift in dramatic and destabilizing ways, shaped by intensifying geopolitical rivalries and rapid technological change. Russia's war in Ukraine, now in its fourth year, drives much of this change. Moscow has escalated nuclear threats, abandoned arms control commitments, and used nuclear signaling to deter Western support for Kyiv. These actions erode long-standing norms of restraint and push nuclear weapons back to the center of major power competition.

China has accelerated its nuclear buildup at a pace unseen in decades, expanding its arsenal and diversifying delivery systems in ways that directly challenge U.S. and allied strategic planning. North Korea has sharpened its nuclear rhetoric, while Iran has advanced weaponization potential. These trends strain the already fragile nonproliferation regime and test the resilience of international agreements meant to limit nuclear dangers.

New technologies compound these pressures. Hypersonic weapons, AI, autonomous systems, and cyber capabilities are reshaping military planning and raising difficult questions about deterrence and escalation. These innovations compress decision times, blur the lines between conventional and nuclear operations, and heighten the risks of miscalculation.

Policymakers, scholars, and the public increasingly recognize the urgency of these challenges. Nuclear modernization, the collapse of arms control, and disruptive technologies demand fresh perspectives and multidisciplinary approaches. Meeting today's nuclear threats requires technical expertise, policy innovation, and a willingness to rethink inherited assumptions about deterrence and stability.

Recognizing the challenges and opportunities, 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. PONI seeks to revitalize and strengthen the community of nuclear experts, whose training and background increasingly emphasize multidisciplinary expertise, especially among younger generations. PONI runs two signature programs for young professionals—the Nuclear Scholars Initiative and the Annual Conference Series—to engage rising nuclear experts in thoughtful and informed debate on how to best address the nuclear community's most critical issues. This volume is comprised of papers from participants in the 2025

Nuclear Scholars Initiative. PONI sponsors this research to provide a forum for facilitating new and innovative thinking and providing a platform for fresh thought leaders across the nuclear enterprise. Through a process of peer review, mid-career mentorship, and senior expert review, nuclear scholars are encouraged to immerse themselves in tough questions with unknown solutions.

The papers in this volume span a wide range of policy, strategic, and technical issues, advancing discussions in their respective areas and offering innovative recommendations for today's nuclear challenges. These contributions address critical intersections of technology and strategy, including the role of Industry 4.0 and cloud manufacturing in the nuclear security enterprise; the integration of AI in arms control, situational awareness, and command and control; and the use of historical analogies and fictional narratives to frame emerging risks. They also explore escalation dynamics and great power competition, Russia's novel nuclear systems, China's nuclear breakout, nuclear-armed anti-satellite weapons, and the broader implications of nuclear modernization.

The volume further investigates regional dynamics, such as India's naval buildup and its impact on the Indian Ocean, Kazakhstan's nuclear diplomacy, and North Korea's command and control arrangements, alongside broader challenges of crisis management and strategic stability. These include the effects of advanced interceptors, non-nuclear strategic weapons, and targeting restrictions on deterrence and escalation control. Additional contributions assess the evolving nuclear order in the Middle East, with analyses of Saudi Arabia's options, as well as debates on sufficiency through tabletop exercises.

Finally, the role of allies and partners is examined through studies of the United Kingdom's contributions to Baltic reassurance, NATO's evolving deterrence posture, and the debates surrounding U.S. nuclear weapons sharing in the Indo-Pacific. Together, these papers underscore the complexity of adapting to the new nuclear age, where technological change, geopolitical competition, and alliance dynamics interact to shape strategic stability.

Industry 4.0 and the Nuclear Nexus



Is AI “Worth the Squeeze” for NC3?

Engineering Trust in AI Nuclear Enterprises

By Andrew Fishberg¹

INTRODUCTION

Artificial intelligence (AI) has emerged as a powerful, general purpose technology actively reshaping education, economies, and even the global balance of power. While industry races ahead with a “move fast and break things” motto, hoping to capture the emerging market’s promised cost savings, productivity gains, and a competitive advantage, more risk-averse sectors—such as the military and nuclear enterprise—are left with a far more complex calculus. Although these sectors recognize AI’s immense potential, lingering questions of trust, confidence, and safety leave experts debating how this technology could, or should, be leveraged in safety-critical settings. In nuclear command, control, and communications (NC3), where even minor errors can have catastrophic implications, average case performance is insufficient; to establish technological trust, decisionmakers require assurances about worst-case behavior and provable guarantees about system reliability.

The ability to prove that a particular AI system will never falter under standard operating conditions is the holy grail of AI verification, a dream that is becoming a reality for certain classes of AI problems. Within NC3, understanding how these emerging AI verification techniques work, when

1 Andrew Fishberg is a PhD student at MIT studying robotics, computer science, and AI. His research develops multi-agent mapping algorithms in service of nuclear nonproliferation. This work has been recognized with multiple awards by national lab representatives through the National Nuclear Security Administration and the Consortium for Enabling Technologies and Innovation. Prior to his graduate work, Andrew was associate staff in the Advanced Capabilities and Systems Group at MIT Lincoln Laboratory, where he developed swarm robotics technology. The author is deeply grateful to Heather Williams and the entire PONI team for their teaching, mentorship, and generosity throughout the 2025 Nuclear Scholar Program. He would also like to thank Lauren Kahn, Sarah Scheffler, and Eleni Ekmektsioglou for reading drafts of this manuscript and providing invaluable feedback. ChatGPT was used in the preparation of this manuscript for sentence refinement.

they apply, and where their limitations lie will be essential for establishing the common language and mutual understandings required for facilitating productive domestic policy and international agreements for safeguarding the—seemingly inevitable—partial integration of AI into the nuclear pipeline. While these new techniques have clear parallels to classic safety engineering practices, missing technical details and insufficient AI terminology often obstruct productive discussions about what kinds of systems can be safely deployed.²

This paper aims to facilitate discussions on the use of AI in NC3 situations through the examination of three sets of questions. First, what is AI and why has it been so hard to define? Second, can AI be used safely and, if so, how and in what contexts? Finally, what NC3-specific safety-first language would enable AI-system discussions in the nuclear context? The answers to these questions provide a possible taxonomic starting point for the productive integration and use of AI in NC3 decisions.

The NC3 pipeline can be understood in terms of five critical functions: situation monitoring, planning, decisionmaking, force direction, and force management.³ The NC3 pipeline is long overdue for modernization, and anyone who has tinkered with modern AI can see that its general purpose techniques could benefit many niches within this pipeline, but at what risk?⁴

AI IS GENERAL PURPOSE AND DUAL-USE

As Horowitz and others have observed, AI is best understood as a general purpose technology, akin to electricity or the internal combustion engine.⁵ In fact, it is so potentially useful and broadly applicable that it is hard to imagine a future where AI does not become embedded somewhere within the NC3 pipeline, with the growing consensus being not questions of “if,” but rather “by whom, when, and to what degree?”⁶ The lines between civilian and military applications are blurred; the same neural network architecture that detects tumors in radiology scans could be repurposed to target missiles with satellite imagery, making AI inherently dual-use.⁷

Although AI is not a weapon in the same sense as a nuclear warhead, it risks amplifying the destabilizing effects of advanced weaponry.⁸ For example, AI has the potential to streamline military

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- 2 Michael Horowitz and Lauren Kahn, “The AI Literacy Gap Hobbles American Officialdom,” *War on the Rocks*, January 14, 2020, <http://warontherocks.com/2020/01/the-ai-literacy-gap-hobbling-american-officialdom/>.
 - 3 Alice Saltin I, Sylvia Mishra, and Philip Reiner, *Nuclear Command, Control & Communications: A Primer on Strategic Warning, Decision Support, and Adaptive Targeting Subsystems* (Oakland: Institute for Security and Technology, July 2025), <https://securityandtechnology.org/wp-content/uploads/2025/07/NC3-Primer-on-Strategic-Warning-Decision-Support-and-Adaptive-Targeting-Subsystems.pdf>.
 - 4 Heather Williams, “Updating Nuclear Command, Control, and Communication,” CSIS, *Commentary*, December 10, 2024, <https://www.csis.org/analysis/updating-nuclear-command-control-and-communication>; and Charles Glaser, Austin Long, and Brian Radzinsky, eds. *Managing U.S. Nuclear Operations in the 21st Century* (Washington, DC: Brookings Institution Press, 2022).
 - 5 Michael C. Horowitz, “Artificial Intelligence, International Competition, and the Balance of Power,” *Texas National Security Review* 1, no. 3 (May 2018): 36–57, <https://tnsr.org/2018/05/artificial-intelligence-international-competition-and-the-balance-of-power/>.
 - 6 James Johnson, “AI, Autonomy, and the Risk of Nuclear War,” *War on the Rocks*, July 29, 2022, <https://warontherocks.com/2022/07/ai-autonomy-and-the-risk-of-nuclear-war/>.
 - 7 James Johnson, “The End of Military-Techno Pax Americana? Washington’s Strategic Responses to Chinese AI-Enabled Military Technology,” *Pacific Review* 34, no. 3 (2019): 351–78, <https://doi.org/10.1080/09512748.2019.1676299>.
 - 8 Michael C. Horowitz and Erik Lin-Greenberg, “Algorithms and Influence Artificial Intelligence and Crisis Decision-Making,” *International Studies Quarterly* 66, no. 4 (2022): sqac069, <https://doi.org/10.1093/isq/sqac069>; James Johnson, “Inadvertent Escalation in the Age of Intelligence Machines: A New Model for Nuclear Risk in the Digital Age,” *European Journal of International Security* 7, no. 3 (2022): 337–59, <https://doi.org/10.1017/eis.2021.23>; James Johnson, “Deterrence in the Age of Artificial Intelligence & Autonomy: A Paradigm Shift in Nuclear Deterrence Theory and Practice?,” *Defense & Security Analysis* 36, no. 4 (2020): 422–48, <https://doi.org/10.1080/14751798.2020.1857911>; Alice Saltini and Yanliang Pan,

operations, increasing the speed of conflict and compressing decisionmaking timeframes. Because of the risks associated with these increased pressures, including the push to integrate AI prematurely out of fear of falling behind, the international community must engage diplomatically to establish ironclad norms and extend the nuclear taboo to unverifiable AI, much as failing to track nuclear waste has become taboo because of the risks it poses to global security.

Though calls for “AI arms control” echo nuclear nonproliferation debates, AI defies traditional frameworks.⁹ Specifically, algorithms lack isotopic signatures, data centers are neither uniquely weaponized nor easily monitored, and software can be copied or altered instantly. Lessons from chemical and biological weapons treaties help but fall short.¹⁰ As AI is more democratized, with open-source tools available to anyone from nation-states to hobbyists, managing it will require new norms and standards tailored to its distinctive risks and contexts.¹¹ How these risks converge into a coherent international strategy remains an open question.¹²

THE “WILD WEST” OF AI DEVELOPMENT

The promises of AI remain speculative, whether a tech CEO chooses to frame the next news cycle around a glorious AI utopia or an off-brand Terminator hellscape.¹³ Many current claims are overhyped, and despite impressive recent gains, there are reasons to believe large language models

“Beyond Human-in-the-Loop: Managing AI Risks in Nuclear Command-and-Control,” War on the Rocks, December 6, 2024, <https://warontherocks.com/2024/12/beyond-human-in-the-loop-managing-ai-risks-in-nuclear-command-and-control/>; James Johnson, “Nuclear Brinkmanship in AI-Enabled Warfare: A Dangerous Algorithmic Game of Chicken,” War on the Rocks, September 28, 2023, <https://warontherocks.com/2023/09/nuclear-brinkmanship-in-ai-enabled-warfare-a-dangerous-algorithmic-game-of-chicken/>; and Michael E. O’Hanlon, “Artificial Intelligence, International Security, and the Risk of War,” Brookings, November 19, 2024, <https://www.brookings.edu/articles/artificial-intelligence-international-security-and-the-risk-of-war/>.

- 9 Henry A. Kissinger and Graham Allison, “The Path to AI Arms Control: America and China Must Work Together to Avert Catastrophe,” *Foreign Affairs*, October 13, 2023, <https://www.foreignaffairs.com/united-states/henry-kissinger-path-artificial-intelligence-arms-control>. For discussions about AI and traditional frameworks for arms control, see Michael C. Horowitz and Lauren A. Kahn, “Nuclear Non-Proliferation Is the Wrong Framework for AI Governance,” *AI Frontiers*, June 27, 2025, <https://ai-frontiers.org/articles/nuclear-non-proliferation-is-the-wrong-framework-for-ai-governance>; and Ian J. Stewart, “Why the IAEA Model May Not Be Best for Regulating Artificial Intelligence,” *Bulletin of the Atomic Scientists*, June 9, 2023, <https://thebulletin.org/2023/06/why-the-iaea-model-may-not-be-best-for-regulating-artificial-intelligence/>.
- 10 For examples from chemical and biological weapons treaties, see Akash R. Wasil et al., “Governing Dual-Use Technologies: Case Studies of International Security Agreements and Lessons for AI Governance,” arXiv, arXiv:2409.02779, submitted September 4, 2024, <https://doi.org/10.48550/arXiv.2409.02779>; and Jane Vaynman and Tristan A. Volpe, “Dual Use Deception: How Technology Shapes Cooperation in International Relations,” *International Organization* 77, no. 3 (2023): 599–632, <https://doi.org/10.1017/S0020818323000140>. For the limitations in the context of AI and arms control, see Megan Lamberth and Paul Scharre, “Arms Control for Artificial Intelligence,” *Texas National Security Review* 6, no. 2 (Spring 2023): 95–110, <https://tnsr.org/2023/05/arms-control-for-artificial-intelligence/>; and Paul Scharre and Megan Lamberth, *Artificial Intelligence and Arms Control* (Washington, DC: Center for a New American Security, October 12, 2022), <https://www.cnas.org/publications/reports/artificial-intelligence-and-arms-control>.
- 11 Jill Hruby and M. Nina Miller, “Assessing and Managing the Benefits and Risks of Artificial Intelligence in Nuclear-Weapon Systems,” Nuclear Threat Initiative, August 26, 2021, <https://www.nti.org/analysis/articles/assessing-and-managing-the-benefits-and-risks-of-artificial-intelligence-in-nuclear-weapon-systems/>; and Thomas Reinhold et al., “Artificial Intelligence, Non-Proliferation and Disarmament: A Compendium on the State of the Art,” EU Non-Proliferation and Disarmament Consortium, *Non-Proliferation and Disarmament Papers* no. 92 (January 2025), https://www.sipri.org/sites/default/files/2025-01/eunpdc_no_92_0.pdf.
- 12 Zac Rogers, “Have Strategists Drunk the ‘AI Race’ Kool-Aid?,” War on the Rocks, June 4, 2019, <https://warontherocks.com/2019/06/have-strategists-drunk-the-ai-race-kool-aid/>; and Marion Messmer, “What Happens If AI Goes Nuclear?,” Chatham House, June 9, 2025, <https://www.chathamhouse.org/publications/the-world-today/2025-06/what-happens-if-ai-goes-nuclear>.
- 13 Kylie Robison, “Anthropic’s CEO Thinks AI Will Lead to a Utopia—He Just Needs a Few Billion Dollars First,” *The Verge*, October 16, 2024, <https://www.theverge.com/2024/10/16/24268209/anthropic-ai-dario-amodei-agi-funding-blog>; Thibault Spirlet, “Elon Musk Says Everyone Will Want Their ‘Personal Robot’—but Warns of ‘Terminator’-Style Risks,” *Business Insider*, May 14, 2025, <https://www.businessinsider.com/elon-musk-personal-robots-warns-terminator-style-risks-saudi-robot-taxi-2025-5>.

(LLMs) like ChatGPT will plateau before achieving artificial general intelligence (AGI).¹⁴ The truth is no one can honestly claim to know the eventual impacts or limits of AI.

While their rhetoric often appears strategically crafted to generate media attention, many leading AI figures share this sense of uncertainty.¹⁵ The competitive business environment and lack of clear norms have spurred a race to deploy new technologies, mirrored in the defense sector, where pressures stem from global power dynamics rather than profit.

Much of today's AI development appears to run in reverse. Traditional engineering starts with a deep study of a problem and then designs a tailored solution, building trust through understanding (e.g., the V-model).¹⁶ By contrast, modern AI often collects massive amounts of domain data, applies general purpose machine learning at scale, and produces state-of-the-art results.¹⁷ Yet these systems remain largely black boxes.¹⁸ Richard Sutton's "bitter lesson" highlights how general, computation-driven methods consistently outperform handcrafted expertise, while Geoffrey Hinton notes that billion-parameter systems "work much better than they have any right to," underscoring the current lack of explanation.¹⁹ This gap between performance and understanding undermines trust, a problem easily overlooked in low-stakes domains like chatbots but potentially catastrophic in cyber-physical systems, national defense, nuclear arms control, or autonomous weapons.²⁰

HUMANS IN THE LOOP: AN IMPERFECT STOPGAP FOR TRUST

In a scenario where a system can be trusted to perform a task as well as, or better than, a human, delegation becomes natural—even preferable. This is the essence of technological progress: Society now relies on GPS instead of compasses, slide rules, or sextants. This trust is well founded. GPS is not only highly reliable in practice, but its accuracy can also be explicitly quantified using physical measurements (e.g., signal strength) and mathematical models grounded in geometry, statistics, and linear algebra. These considerations yield a useful reliability metric known as dilution of precision (DOP), often visualized as the light-blue uncertainty region surrounding a location indicator in mapping applications.²¹ Well-made GPS receivers have been shown to achieve a horizontal accuracy of 3 meters (approximately 9.8 feet) or better 95 percent of the time, which is sufficient for everyday

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- 14 Gary Marcus, "When Billion-Dollar AIs Break Down over Puzzles a Child Can Do, It's Time to Rethink the Hype," *The Guardian*, June 10, 2025, <https://www.theguardian.com/commentisfree/2025/jun/10/billion-dollar-ai-puzzle-break-down>; and Tom Villani, "How Close Is AGI Actually? Why LLMs Alone Will Not Get Us to AGI," New Jersey Innovation Institute, July 17, 2024, <https://www.njii.com/2024/07/why-llms-alone-will-not-get-us-to-agi/>.
 - 15 Eric Hal Schwartz, "OpenAI's CEO Says He's Scared of GPT-5," *Techradar*, July 28, 2025, <https://www.techradar.com/ai-platforms-assistants/chatgpt/openai-ceo-says-hes-scared-of-gpt-5>; Steve Rose, "Demis Hassabis on Our AI Future: 'It'll Be 10 Times Bigger than the Industrial Revolution—and Maybe 10 Times Faster,'" *The Guardian*, August 4, 2025, <https://www.theguardian.com/technology/2025/aug/04/demis-hassabis-ai-future-10-times-bigger-than-industrial-revolution-and-10-times-faster>.
 - 16 Roger S. Pressman, *Software Engineering: A Practitioner's Approach*, 6th ed. (Columbus, OH: McGraw-Hill, 2005).
 - 17 Will Henshall, "4 Charts That Show Why AI Progress Is Unlikely to Slow Down," *TIME*, August 2, 2023, <https://time.com/6300942/ai-progress-charts/>.
 - 18 Xuhong Li et al., "Interpretable Deep Learning: Interpretation, Interpretability, Trustworthiness, and Beyond," *Knowledge and Information Systems* 64 (2022): 3197–234, <https://doi.org/10.1007/s10115-022-01756-8>.
 - 19 Richard Sutton, "The Bitter Lesson," *IncompleteIdeas.net*, March 13, 2019, <http://www.incompleteideas.net/Incldeas/BitterLesson.html>; and Richard Sutton and Andrew G. Barto, *Reinforcement Learning: An Introduction*, 2nd edition (Cambridge, MA: MIT Press, 2018). For Hinton, see Nicholas Thompson, "An AI Pioneer Explains the Evolution of Neural Networks," *Wired*, May 13, 2019, <https://www.wired.com/story/ai-pioneer-explains-evolution-neural-networks/>.
 - 20 Molly Kovite, "I, Black Box: Explainable Artificial Intelligence and the Limits of Human Deliberative Processes," *War on the Rocks*, July 5, 2019, <https://warontherocks.com/2019/07/i-black-box-explainable-artificial-intelligence-and-the-limits-of-human-deliberative-processes/>.
 - 21 Richard B. Langley, "Dilution of Precision," *GPS World* 10, no. 5 (1999): 52–9.

navigation.²² However, the same metric also clarifies GPS's limitations: It is not precise enough to serve as the sole source of state estimation for autonomous vehicles, as its accuracy cannot reliably distinguish between a vehicle's lane and the adjacent lane only a few feet away.

When a system is not fully trusted and errors carry serious consequences, a “human in the loop” can buffer against automation failure, but only if integrated effectively. Operators should enhance machine performance by applying superior situational awareness and judgment. For example, while humans are slow and error-prone at reading barcodes manually, they are much better at checking whether the item scanned actually matches what appears on the screen, making them effective at catching mistakes.

Yet this approach is far from foolproof.²³ Infrequently needed interventions and high stakes foster automation bias—operators overly trust automation despite knowing its limits.²⁴ Civilian and military cases alike (e.g., self-driving crashes and Patriot missile misfires) demonstrate the challenges of maintaining vigilance in rare-failure environments.²⁵ This setup can also risk shifting disproportionate legal or moral responsibility onto a single operator rather than the system's creators.²⁶

More complex human-machine teaming, such as analysts working alongside LLMs—the “centaur model”—magnifies these risks.²⁷ Bias in AI outputs can shape human decisions, while human biases reinforce the system's outputs, creating self-reinforcing feedback loops.²⁸ This has understandably raised concerns about the potential effects of these systematic biases if they are incorporated into a nation's intelligence apparatus.²⁹ LLMs illustrate this danger, as their vast training data, stochastic behavior, and acknowledged issues such as sycophancy make neutrality difficult to guarantee.³⁰ They

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- 22 U.S. Department of Defense, *Global Positioning System Standard Positioning Service Performance Standard*, 5th ed. (Washington, DC: U.S. Department of Defense, April 2020), <https://www.gps.gov/sites/default/files/2025-07/2020-SPS-performance-standard.pdf>.
- 23 Lauren Kahn, Emelia Probasco, and Ronnie Kinoshita, “AI Safety and Automation Bias: The Downside of Human-in-the-Loop,” Center for Security and Emerging Technology, November 2024, <https://cset.georgetown.edu/publication/ai-safety-and-automation-bias/>.
- 24 Kate Goddard, Abdul Roudsari, and Jeremy C. Wyatt, “Automation Bias: A Systematic Review of Frequency, Effect Mediators, and Mitigators,” *Journal of the American Medical Informatics Association* 19, no. 1 (2012): 121–7, <https://pmc.ncbi.nlm.nih.gov/articles/PMC3240751/>.
- 25 Lauren Smiley, “The Legal Saga of Uber's Fatal Self-Driving Car Crash Is Over,” *Wired*, July 28, 2023, <https://www.wired.com/story/ubers-fatal-self-driving-car-crash-saga-over-operator-avoids-prison/>; Joan Lowy and Tom Krisher, “Tesla Driver Killed in Crash While Using Car's Autopilot,” AP, June 30, 2016, <https://apnews.com/united-states-government-ee71bd-075fb948308727b4bbff7b3ad8>; David Axe, “In 2003, No One Hated U.S. Army Patriot Missiles More than U.S. Air Force Pilots,” *National Interest*, September 9, 2021, <https://nationalinterest.org/blog/reboot/2003-no-one-hated-us-army-patriot-missiles-more-us-air-force-pilots-193342/>; John K. Hawley, *Looking Back at 20 Years of MANPRINT on Patriot: Observations and Lessons* (Fort Belvoir, VA: Defense Technical Information Center, September 2007), <https://apps.dtic.mil/sti/html/tr/ADA472740/index.html>; and Charles Piller, “Vaunted Patriot Missile Has a ‘Friendly Fire’ Failing,” *Los Angeles Times*, April 21, 2003, <https://www.latimes.com/archives/la-xpm-2003-apr-21-war-patriot21-story.html>.
- 26 For a case in point, see Bernard Condon and David Fischer, “Jury Orders Tesla to Pay More than \$240 Million in Autopilot Crash Case,” AP, August 1, 2025, <https://apnews.com/article/tesla-miami-musk-benavides-selfdriving-autopilot-autonomous-vehicles-c342f2716b1ec4e9ede09b8e958751b7>.
- 27 For a discussion of the centaur model, see Soroush Saghaian, “Effective Generative AI: The Human-Algorithm Centaur,” Harvard Kennedy School Working Paper No. RWP23-030, October 2023, <https://www.hks.harvard.edu/publications/effective-generative-ai-human-algorithm-centaur>. See also James Johnson, “Is There a Human in the Machine? AI and Future Warfare,” *War on the Rocks*, May 30, 2024, <https://warontherocks.com/2024/05/is-there-a-human-in-the-machine-ai-and-future-warfare/>.
- 28 Moshe Glickman and Tali Sharot, “How Human-AI Feedback Loops Alter Human Perceptual, Emotional and Social Judgments,” *Nature Human Behaviour* 9 (2024): 345–59, <https://doi.org/10.1038/s41562-024-02077-2>.
- 29 Michael C. Horowitz and Lauren Kahn, “Bending the Automation Bias Curve: A Study of Human and AI-Based Decision Making in National Security Contexts,” *International Studies Quarterly* 68, no. 2 (2024): sqae020, <https://doi.org/10.1093/isq/sqae020>.
- 30 Adam Tauman Kalai, Ofir Nachum, Santosh S. Vempala, and Edwin Zhang, “Why Language Models Hallucinate,” arXiv, arX-

are also susceptible to “data poisoning,” where biased (potentially adversarial) content infiltrates training data.³¹

Human-in-the-loop safety remains valuable but imperfect. Not only are humans fallible, they also risk absorbing the same embedded or adversarial biases present in the systems they oversee—risks that are especially consequential within the NC3 pipeline.

AI IS SURPRISINGLY HARD TO DEFINE, LET ALONE REGULATE

Why is it so hard to converge on workable solutions for AI safety, especially given the existential stakes of nuclear enterprise? Although U.S. commitments to “human in the loop” for NC3 and policy statements promising AI use “should not compromise the integrity of nuclear safeguards” are good steps, the umbrella term “AI” remains almost as broad as the subjects of “math” or “science.”³² While strategic ambiguity can help potentially adversarial states reach agreements (e.g., the vague definition of “pursue negotiations in good faith” in Article VI of the Non-Proliferation Treaty), it also risks creating loopholes that undermine risk reduction.³³ Thus, while terminology for autonomous weapons and their ethics has advanced, AI remains a fluid, evolving concept still in need of sharper definitions for effective governance and arms control.

The term “AI” carries a mystique that often obscures more than it clarifies. Consider the U.S. legal definition from 15 U.S. Code § 9401, which describes AI as any “machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments.”³⁴ By that definition, an Excel spreadsheet fitting a straight line to data (i.e., linear regression, a statistical method developed centuries ago) would qualify as AI. This is clearly not what most people mean when they refer to AI. Additionally, by this definition, any nuclear-launch detection system—which ultimately involves raw sensor data (far beyond human capacity to interpret in real time) being fed into algorithmic signal-processing filters with tuned parameters to determine whether a threshold has been reached to trigger an alert—would qualify as AI. With that logic, AI has been in the nuclear pipeline since the early days of the Cold War and is not that different from previous technologies. But again, this is not what most people mean when they talk about AI.

Many people point to scale as the distinguishing feature of modern AI, gesturing toward plots of the exponential growth of datasets, connections between artificial neurons, or the number of artificial neurons in AI systems, but even so, deciding on a meaningful cutoff between “AI” and “not AI” is extremely difficult.³⁵

This inability to clearly define the boundaries of what counts as AI leads both policymakers and technologists to often default to an “I know it when I see it” standard. But it is worth emphasizing how unusual this is: Scientists, of all people, are trained to rigorously define, categorize, and classify

iv:2509.04664, September 4, 2025, <https://doi.org/10.48550/arXiv.2509.04664>; and “Expanding on What We Missed with Sycophancy,” OpenAI, May 2, 2025, <https://openai.com/index/expanding-on-sycophancy/>.

31 Yifan Yao et al., “A Survey on Large Language Model (LLM) Security and Privacy: The Good, The Bad, and The Ugly,” *High-Confidence Computing* 4, no. 2 (2024): 100211, <https://doi.org/10.1016/j.hcc.2024.100211>.

32 National Defense Authorization Act for Fiscal Year 2025, Pub. L. No. 118-159, 138 Stat. 1773 (2024), Section 1638.

33 Treaty on the Non-Proliferation of Nuclear Weapons, U.K.-U.S.-U.S.S.R., April 22, 1970, International Atomic Energy Agency, INF/CIRC/140, <https://www.iaea.org/sites/default/files/publications/documents/infcircs/1970/infcirc140.pdf>.

34 “15 U.S. Code § 9401—Definitions,” Legal Information Institute (LII), accessed September 5, 2025, <https://www.law.cornell.edu/uscode/text/15/9401>.

35 Ian Goodfellow, Yoshua Bengio, and Aaron Courville, *Deep Learning* (Cambridge, MA: MIT Press, 2016), <https://www.deeplearningbook.org/contents/intro.html>.

the concepts with which they work. The fact that leading experts struggle to produce a clear, succinct definition of AI without shifting into discussions of rationality, philosophy, and utilitarian versus deontological ethics suggests that the challenge is not technological at its core.³⁶ Rather, it stems from the difficulty of translating a fuzzy societal perception into precise technical language.

All of this is to say that it is not that 15 U.S. Code § 9401 is incorrect in its definition, but rather that accurately defining the broad umbrella-term AI succinctly is a surprisingly challenging task. To be technically precise, the author uses the following definitions for the purposes of this paper:

1. Although the terms “AI” and “machine learning” are often used interchangeably in colloquial speech, machine learning is a specific subfield of AI focused on statistical algorithms such as neural networks, deep learning, and LLMs.³⁷ In this author’s experience, this is what people seem to be alluding to when discussing “modern AI.”
2. For the purposes of this analysis, AI is a colloquial rephrasing of machine learning’s universal approximation theorem, which states that any sufficiently sophisticated neural network can, in theory, approximate any arbitrary continuous function to any specified degree of accuracy.³⁸

In practice, this means that—especially in domains demanding precision, such as NC3—practitioners need to develop new, specialized terminology, with distinctions drawn at policy- and safety-relevant boundaries to enable more productive conversations.³⁹

HOW DOES ONE GAIN TRUST AND CONFIDENCE IN AI?

Trust in human systems relies on accountability. When a distracted driver causes a fatal accident, authorities can identify the actor and impose legal consequences. This incentivizes good practice and satisfies a moral intuition—justice demands retribution, which requires attribution.

While the accountability of self-driving cars remains unsettled in civilian life, the military has no such ambiguity. Under the doctrine of command responsibility, a commander may delegate authority but never responsibility, remaining answerable for subordinates’ actions even when not directly ordered.⁴⁰ This has important implications for AI—a commander who cannot fully grasp a potent tool’s risks should not deploy it. They remain liable for malfunctions and unintended consequences yet must still seek every advantage. Building trust and confidence in AI is therefore essential.

Nuclear systems have long embraced rigorous risk and safety analysis, but AI presents a new

36 Stuart J. Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach*, 4th ed. (London: Pearson, 2021).

37 Simon J. D. Prince, *Understanding Deep Learning* (Cambridge, MA: MIT Press, 2023); and Olufisayo S. Ekundayo and Absalom E. Ezugwu, “Deep Learning: Historical Overview from Inception to Actualization, Models, Applications and Future Trends,” *Applied Soft Computing* 181 (September 2025): 113378, <https://doi.org/10.1016/j.asoc.2025.113378>.

38 Kurt Hornik, Maxwell Stinchcombe, and Halbert White, “Multilayer Feedforward Networks Are Universal Approximators,” *Neural Networks* 2, no. 5 (1989): 359–66, [https://doi.org/10.1016/0893-6080\(89\)90020-8](https://doi.org/10.1016/0893-6080(89)90020-8).

39 For interested readers, discussion of AI trust and confidence can be found in a general framework in Sarah Kreps, Julie George, Paul Lushenko, and Adi Rao, “Exploring the Artificial Intelligence ‘Trust Paradox’: Evidence from a Survey Experiment in the United States,” *PLOS ONE* 18, no. 7 (2023): e0288109, <https://doi.org/10.1371/journal.pone.0288109>; and in a national security framework in Margarita Konaev, Tina Huang, and Husanjot Chahal, “Trusted Partners: Human-Machine Teaming and the Future of Military AI,” Center for Security and Emerging Technology, February 2021, <https://cset.georgetown.edu/publication/trusted-partners/>; and Paul Scharre, *Army of None: Autonomous Weapons and the Future of War National Defense* (New York: W.W. Norton, 2018).

40 Joe Doty and Chuck Doty, “Command Responsibility and Accountability,” *Military Review* 92, no. 1 (January–February 2012), 35–38, <https://www.armyupress.army.mil/Journals/Military-Review/English-Edition-Archives/MR-90th-Anniversary/90th-Doty/>.

paradigm.⁴¹ Useful lessons come from the auto industry, which has struggled to standardize safety and certification practices for self-driving cars. As the first major sector forced to address physical-safety risks in black-box AI systems, the self-driving industry offers hard-won lessons that should be carried into NC3 rather than rediscovered. Although still relatively risk-averse, the self-driving industry is ultimately far more risk tolerant than the nuclear community (e.g., see Ottomotto’s “safety third” slogan).⁴² These more permissive safety practices should be considered the bare minimum for NC3. Despite its head start adoption and far less adversarial environment, the auto industry has struggled to define satisfactory safety certification standards, a warning of the challenges facing NC3.⁴³

AI AND DATA-DRIVEN LEARNING

Consider *expected risk* (cost) from a probabilistic perspective of expectation:⁴⁴

$$\text{Expected Risk} = \text{Chance of Consequence} \times \text{Cost of Consequence}$$

This can be seen as the foundational business model of insurance companies. But this model has two often-overlooked flaws for high-risk, low-frequency systems:

1. Meaningfully quantifying risk at the extremes becomes difficult or even impossible. Although nuclear analysts do their best to mitigate this, at some point the math⁴⁵

$$\text{Expected Risk} = \text{Practically Never} \times \text{Existentially Catastrophic}$$

stops being a satisfying model⁴⁶—as in $\frac{1}{10^{80}} \times \infty = \infty$, an “unbounded risk” scenario.

2. A purely testing (data-driven) approach to system certification becomes prohibitively ineffective when the chance of consequence is extremely low. Consider the following self-driving car facts put forth by Shalev-Shwartz et al. and others:⁴⁷
 - Human drivers have roughly a one-in-a-million (10^{-6}) chance of death per hour of driving.

41 John C. Lee and Norman J. McCormick, *Risk and Safety Analysis of Nuclear Systems* (Hoboken, NJ: Wiley, 2011).

42 Anita Balakrishnan, “Engineers at Uber’s Self-Driving Unit Passed Around ‘Safety Third’ Stickers as a Joke,” CNBC, March 16, 2017, <https://www.cnbc.com/2017/03/16/anthony-levandowski-ubers-self-driving-car-engineer-safety-lawsuit.html>.

43 Philip Koopman, “Adapting ANSI/UL 4600 Into A Self-Driving Regulatory Standard,” *Autonomous System Safety by Phil Koopman* (blog), Substack, May 27, 2025, <https://philkoopman.substack.com/p/using-ansiul-4600-as-a-self-driving>; Philip Koopman, “Tesla Deployment Gets Messy. Should We Worry?,” *Autonomous System Safety by Phil Koopman* (blog), Substack, June 25, 2025, <https://philkoopman.substack.com/p/tesla-deployment-gets-messy-should>; and Noah Goodall, “Normalizing Crash Risk of Partially Automated Vehicles Under Sparse Data,” *Journal of Transportation Safety & Security* 16, no. 1 (2024): 1–17, <https://doi.org/10.1080/19439962.2023.2178566>. For more on autonomous vehicle safety and philosophy by Philip Koopman, see his *How Safe Is Safe Enough?: Measuring and Predicting Autonomous Vehicle Safety* (self-published, 2022); and his *Embodied AI Safety: Reimagining Safety Engineering for Artificial Intelligence in Physical Systems* (self-published, 2025).

44 Sayan Mitra, *Verifying Cyber-Physical Systems: A Path to Safe Autonomy* (Cambridge, MA: MIT Press, 2021).

45 Office of Technology Assessment, *The Effects of Nuclear War* (Washington, DC: Government Printing Office, 1979), <https://ota.fas.org/reports/7906.pdf>.

46 “L128 Autonomous Vehicles and Software Safety Engineering,” YouTube video, posted by Phil Koopman, May 12, 2022, 40:37, 5:18, https://www.youtube.com/watch?v=oE_2rBxNrfc.

47 Shai Shalev-Shwartz, Shaked Shammah, and Amnon Shashua, “On a Formal Model of Safe and Scalable Self-Driving Cars,” arXiv, arXiv:1708.06374, October 27, 2018, <https://doi.org/10.48550/arXiv.1708.06374>; Philip Koopman and Michael Wagner, “Challenges in Autonomous Vehicle Testing and Validation,” *SAE International Journal of Transportation Safety* 4, no. 1 (2016): 15–24, <https://doi.org/10.4271/2016-01-0128>; and Steve Nadis, “How to Guarantee the Safety of Autonomous Vehicles,” *Wired*, February 4, 2024. <https://www.wired.com/story/how-to-guarantee-the-safety-of-autonomous-vehicles-driverless-cars-ai-waymo-cruise-robotaxi-tesla/>.

- Cognitive biases lead users to demand higher safety from automation than from humans to feel equally “safe.”⁴⁸
- Proving a self-driving car is 1,000× safer than a human would require an impractical 10⁹ hours of driving data.

For context, 10⁹ hours of driving is over 110,000 years of continuous driving or over 2.6 million trips around the equator at 65 mph. Worse still, any modifications to the system necessitate recertification, effectively restarting the entire testing effort.

AI methods built on machine learning—whether deep learning, reinforcement learning, or LLMs—share a fundamental limitation: at their core, they are statistical techniques that require vast numbers of examples to “learn” how to respond to different situations.⁴⁹ In traditional engineering, edge cases—situations that occur at the extremes of a program or system—are enumerated and addressed directly; in data-driven learning, the burden shifts to curating abundant training examples of those edge conditions—a herculean task when specific failure modes can occur at less than one-in-a-billion odds. This frequency-to-importance asymmetry explains why “big data” has dominated as a buzzword for over a decade and why analogies equating “data” to “oil” are so commonplace.⁵⁰

Since collecting real data can be costly, synthetic (computer-generated) data can offer a faster and cheaper source of training examples. However, even high-quality synthetic data inevitably differs from reality, which risks causing models to “overfit to the simulator”—learning artifacts of the simulated environment rather than real-world patterns. As a result, systems may perform well in simulation but fail during real deployment (the AI equivalent of excelling in a flight simulator but not in an actual cockpit). Closing this “sim-to-real gap” remains a central research challenge, whether by improving the realism of simulations or designing training methods that encourage models to learn transferable, real-world behaviors.⁵¹

Understanding the centrality of data also clarifies the rapid improvements of LLMs. Even though breakthroughs in foundational models (e.g., LLMs) may appear to show capabilities approaching AGI or general purpose reasoning, they remain rooted in the same statistical methods, prompting some experts to jokingly call LLMs “stochastic parrots,” noting that—like their feathered namesake—LLMs may seem to “talk,” but their replies fall short of true intelligence and are ultimately regurgitated patterns they have learned.⁵² What makes LLMs seem “smarter” than a parrot is simply that their regurgitation patterns are far more convincing.

48 Berit Brogaard, “Explaining Our Extreme Safety Demands for Self-Driving Cars,” *Psychology Today*, March 29, 2021, <https://www.psychologytoday.com/us/blog/the-superhuman-mind/202103/explaining-our-extreme-safety-demands-self-driving-cars>.

49 “L128 Autonomous Vehicles and Software Safety Engineering,” YouTube video, 9:11; and Adam Tauman Kalai, Ofir Nachum, Santosh S. Vempala, and Edwin Zhang, “Why Language Models Hallucinate,” arXiv, arXiv:2509.04664, September 4, 2025, <https://doi.org/10.48550/arXiv.2509.04664>.

50 “The World’s Most Valuable Resource Is No Longer Oil, but Data,” *The Economist*, May 6, 2017, <https://www.economist.com/leaders/2017/05/06/the-worlds-most-valuable-resource-is-no-longer-oil-but-data>; and Christoph Stach, “Data Is the New Oil—Sort of: A View on Why This Comparison Is Misleading and Its Implications for Modern Data Administration,” *Future Internet* 15, no. 2 (2023): 71, <https://doi.org/10.3390/fi15020071>.

51 Wenshuai Zhao, Jorge Peña Queraltá, and Tomi Westurland, “Sim-to-Real Transfer in Deep Reinforcement Learning for Robotics: A Survey,” in *2020 IEEE Symposium Series on Computational Intelligence (SSCI)* (IEEE, 2020), 737–44, <https://ieeexplore.ieee.org/abstract/document/9308468>.

52 Emily Bender et al., “On the Dangers of Stochastic Parrots: Can Language Models Be Too Big?,” in *FAccT’21: Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency* (Association for Computing Machinery, March 2021), 610–23, <https://doi.org/10.1145/3442188.3445922>.

That begs the question, what can be done to build trust and confidence in inherently statistical systems?

AN INTRODUCTION TO SYSTEM VERIFICATION AND FORMAL METHODS

While accuracy is often necessary for trust, it is not sufficient. That said, accuracy is not a surrogate for trust, especially in high-stakes situations. Genuine trust based solely on testing is warranted only if either (1) the tests are exhaustive or (2) the risk is negligible. However, in complex, real-world cyber-physical systems, tests are never exhaustive and human lives are never negligible. A better way to substantiate trust in high-risk environments is therefore needed, such as system verification and formal methods, approaches by no means new to the nuclear enterprise.⁵³

Adapted from Mitra, verification—unlike testing—requires safety engineers to mathematically prove statements such as, “Does system A meet requirements R?”⁵⁴ To do this, there must be both a model of the system and a set of requirements, often expressed as invariants—conditions that must always hold true during operation (e.g., “The vehicle should never come closer than one meter to another vehicle.”). The field of formal methods, despite its generic-sounding name, refers to a specific family of rigorous mathematical techniques used to perform such verification on software or hardware systems. In a kind of convergent evolution, computer science and control theory independently developed many similar formal verification techniques to meet slightly different needs: computer scientists focused on rigorously proving the correctness of complex, discrete software systems (e.g., ensuring no software errors remain unhandled), while control systems engineers sought to verify continuous dynamical systems, modeled as ordinary differential equations (ODEs), for stability and robustness (e.g., ensuring a spacecraft’s attitude controller remains robust to parameter variations). More recently, these two branches have begun cross-pollinating to build trust and confidence in AI systems.⁵⁵

Mathematically “proving safety” for AI can be analogized to civil engineering. Engineers do not simply build a bridge and pile on weight until it is either deemed “safe” or it collapses. Instead, civil engineers follow a process similar to formal verification techniques described above:

53 Mykel J. Kochenderfer et al., *Algorithms for Validation* (Cambridge, MA: MIT Press, forthcoming 2025), <https://algorithms-book.com/validation/files/vaL.pdf>; V. Fortakov, “Nuclear Verification: What It Is, How It Works, the Assurances It Can Provide,” in *Technical Workshop on Safeguards, Verification Technologies, and Other Related Experience*, no. INIS-XA-183 (1998): 41–51, <https://www.osti.gov/etdeweb/servlets/purl/703309>; and Johnathan Falcone, Jonathan Rodriguez Cefalu, Michael Kneeshaw, and Maarten Bos, “Prove It Before You Use It: Nuclear Retaliation Under Uncertainty,” *War on the Rocks*, June 1, 2023, <https://warontherocks.com/2023/06/prove-it-before-you-use-it-nuclear-retaliation-under-uncertainty/>.

54 Mitra, *Verifying Cyber-Physical Systems*.

55 In practice, recent research has focused on creating “provably correct” AI systems, such as neural networks. Sydney M. Katz et al., “Generating Probabilistic Safety Guarantees for Neural Network Controllers,” *Machine Learning* 112 (2023): 2903–31, <https://doi.org/10.1007/s10994-021-06065-9>. For the curious reader, some representative technical works include the following references and cover topics such as safety filters, control barrier functions, and reachability analysis: Kai-Chieh Hsu, Haimin Hu, and Jaime F. Fisac, “The Safety Filter: A Unified View of Safety-Critical Control in Autonomous Systems,” *Annual Review of Control, Robotics, and Autonomous Systems* 7 (2024): 47–72, <https://doi.org/10.1146/annurev-control-071723-102940>; Kim P. Wabersich et al., “Data-Driven Safety Filters: Hamilton-Jacobi Reachability, Control Barrier Functions, and Predictive Methods for Uncertain Systems,” *IEEE Control Systems Magazine* 43, no. 5 (2023): 137–77, <https://doi.org/10.1109/MCS.2023.3291885>; Charles Dawson, Sicun Gao, and Chuchu Fan, “Safe Control With Learned Certificates: A Survey of Neural Lyapunov, Barrier, and Contraction Methods for Robotics and Control,” *IEEE Transactions on Robotics* 39, no. 3 (2023): 1749–67, <https://doi.org/10.1109/TRO.2022.3232542>; and Somil Bansal et al., “Hamilton-Jacobi Reachability: A Brief Overview and Recent Advances,” in *2017 IEEE 56th Annual Conference on Decision and Control (CDC) (IEEE, 2017)*, 2242–53, <https://doi.org/10.1109/CDC.2017.8263977>.

1. Engineers gather detailed informal requirements. What type of traffic will the bridge support? How much weight does that entail? Will the bridge need to withstand earthquakes, hurricanes, or typhoons? Each of these considerations informs the design.
2. They select an appropriate model for construction—one that incorporates mathematical equations based on well-characterized material properties (e.g., steel, concrete, reinforcements) and environmental factors (e.g., corrosion, natural disasters, soil and foundation conditions).
3. They translate informal requirements and tolerances into formal requirements expressed in the mathematical language of the model. While an informal requirement might be, “The bridge needs to support industrial traffic,” a more formalized version (although still in layman’s terms for the sake of example) could be mathematical constraints expressing something like, “The bridge must support one hundred 80,000-pound trucks distributed evenly across its span.”
4. The bridge is designed and, using the mathematical model, formally verified for safety (i.e., confirming that the bridge design meets all specified requirements within the selected model). Uncertainty is represented by the model and formal requirements and mitigated by “over-engineering” (i.e., designing conservatively) to ensure all assumptions can stay well within bounds.
5. The designed bridge is constructed and meticulously inspected to confirm all model assumptions remain valid.

The fifth point is particularly important because it highlights the Achilles’ heel of formal verification: Safety verification guarantees are only as good as the model and formal requirements.⁵⁶ Just as with any mathematical proof, faulty assumptions undermine the entire argument. Likewise, if the underlying model does not adequately represent the stress properties of steel, or the formal requirements do not capture a need to survive a 6.0-magnitude earthquake, for example, the “formal argument” for a safe bridge becomes unsubstantiated. Furthermore, this is why inspections and maintenance are essential: Just because a bridge’s foundation was within specification when built does not mean it will be after 50 years of saltwater corrosion. That said, system corrosion can be accounted for if the model incorporates expected rates of deterioration (i.e., model everything).

This analogy to civil engineering matters for AI for several reasons:

1. Recent advances in **certifiable machine learning** extend the paradigm of provable safety to AI. These tools provide a pathway to trust and confidence for suitable AI systems. (For example, given the well-defined assumptions, whether an autonomous steering AI will always stay 3 m from a pedestrian can be certified.)
2. Engineering safety through **formal verification** shifts the burden from exhaustive testing to accurate system modeling and a complete set of formal requirements. A sophisticated model can explicitly state its sensor assumptions and tolerances, enabling component-level validation. For example, if a light detection and ranging sensor (LIDAR) on a self-driving car needs replacement, only that sensor must be verified to meet its stated assumptions. Once validated, the formal proof of safety extends to the overall system without requiring exhaustive full-system retesting. While still challenging, this prevents repeating billions of hours of full-system testing after every modification.
3. The primary limitation of the verification paradigm is that it is only as good as the underlying

56 Christel Baier and Joost-Pieter Katoen, *Principles of Model Checking* (Cambridge, MA: MIT Press, 2008).

model and formal requirements. It also presumes that users' needs can be accurately modeled and explicitly expressed as formal requirements.

WHEN FORMAL VERIFICATION IS NOT ENOUGH: FAIRNESS AND THE MATHEMATICAL INEVITABILITY OF BIAS

LLMs, with their complexity and high degrees of freedom, make it difficult to guarantee neutrality in responses, which contributes to automation bias. In this context, “bias” and “fairness” mean systematic differences in AI performance. A biased detector fails more often for certain patterns, a dangerous vulnerability in adversarial, high-stakes settings like NC3. This raises the question: Can formal methods and system verification eliminate such bias? Humans are inherently biased, so it is tempting to hope that machines might produce perfectly unbiased judgments. But verification presumes requirements can be formally defined. What, then, is the mathematical expression of “perfect unbiasedness” or “objective fairness?”

The Kleinberg-Chouldechova impossibility theorem demonstrates that perfect unbiasedness is unattainable.⁵⁷ In essence, all error metrics across subgroups can only be equal if either the underlying base rates are identical or if the classifier is a perfect oracle with no errors, conditions that rarely hold in practice.

This impossibility result has broad implications. For concrete objectives—such as ensuring a self-driving car does not hit people—designers can impose extremely low failure thresholds. Even if risks differ slightly across groups (e.g., bicyclists versus pedestrians), both can be kept below safety thresholds, and the informal goal of “not hitting people” remains clear and measurable. By contrast, LLMs lack such concrete goals: Any fairness standard is subjective, shaped by cultural values and design choices, and the impossibility result implies no system can satisfy all fairness definitions simultaneously.⁵⁸ While some wonder if AI could still be “less biased” than humans, this remains unsettled.⁵⁹ What is clear is that fairness claims in LLMs cannot be trusted with the same confidence as systems governed by clear, numerical outcomes.

Because open-ended systems like LLMs lack strong formal guarantees, AI governance—the processes and institutions overseeing AI decisions—and its supporting technical tools have continued to evolve.⁶⁰ A promising approach is AI explainability, which has systems “show their work” so operators can audit outputs against their subjective requirements.⁶¹ Yet explainability remains difficult, and its

57 Deborah Hellman, “Algorithmic Fairness” in *Stanford Encyclopedia of Philosophy*, eds. Edward N. Zalta and Uri Nodelman (Stanford, CA: Stanford University, 2025), last updated June 30, 2025, <https://plato.stanford.edu/archives/fall2025/entries/algorithmic-fairness/>. For 2016 and 2017 mathematical papers that originally derived this theorem, see Jon Kleinberg et al. “Inherent Trade-Offs in the Fair Determination of Risk Scores,” arXiv, arXiv:1609.05807, November 17, 2016, <https://doi.org/10.48550/arXiv.1609.05807>; and Alexandra Chouldechova, “Fair Prediction with Disparate Impact: A Study of Bias in Recidivism Prediction Instruments,” *Big Data* 5, no. 2 (2017): 153–63, <https://doi.org/10.1089/big.2016.0047>.

58 Edmond Awad et al., “The Moral Machine Experiment,” *Nature* 563 (2018): 59–64, <https://doi.org/10.1038/s41586-018-0637-6>.

59 For the unsettled nature of the debate, see Isabel O. Gallegos et al., “Bias and Fairness in Large Language Models: A Survey,” *Computational Linguistics* 50, no. 3 (2024): 1097–179, https://doi.org/10.1162/coli_a_00524.

60 Anka Reuel et al., “Open Problems in Technical AI Governance,” arXiv, arXiv:2407.14981, April 16, 2025, <https://doi.org/10.48550/arXiv.2407.14981>.

61 Gabrielle Ras, Ning Xie, Marcel van Gerven, and Derek Doran, “Explainable Deep Learning: A Field Guide for the Uninitiated,” *Journal of Artificial Intelligence Research* 73 (2022): 329–96, <https://doi.org/10.1613/jair.1.13200>. For how these systems can “show their work,” see Molly Kovite, “I, Black Box: Explainable Artificial Intelligence and the Limits of Human Deliberative Processes,” War on the Rocks, July 5, 2019, <https://warontherocks.com/2019/07/i-black-box-explainable-artificial-intelligence-and-the-limits-of-human-deliberative-processes/>. See also Sajid Ali et al., “Explainable Artificial Intelli-

auditing falls short of ideal provable guarantees, relying instead on institutional structures and social norms to manage uncertainty and automation bias.⁶²

Having outlined verifiable safety and bias in relation to AI, this paper now moves to a possible AI taxonomy for NC3 automation.

DEVELOPING NC3-SPECIFIC SAFETY-FIRST LANGUAGE FOR AI

This section first proposes an AI taxonomy for NC3 automation. While this framework is a proposed delineation of capabilities for AI, it draws from SAE J3016, a proposed terminology standard for self-driving cars.⁶³ SAE J3016 defines six levels of vehicle automation, ranging from Level 0 (i.e., no driving automation) to Level 5 (i.e., full driving automation), where each level raises different questions about reliability, oversight, and how best to balance human and machine roles in self-driving vehicle scenarios. The paper then discusses how each level of this taxonomy pertains to NC3-specific concerns about reliability, oversight, and how best to balance human and machine roles in this critical decisionmaking pipeline.

NC3 AUTOMATION-LEVEL TAXONOMY

- **Level 0: Classical signal processing:** These techniques have been integral to nuclear launch detection systems since the early days of the Cold War. These systems assess whether predefined thresholds have been reached and, if so, trigger an alert to a human operator.
- **Level 1: Augmenting signal processing:** Like systems that flag suspicious credit card transactions, AI can add an extra sensing layer to vast streams of numerical sensor data. This approach builds on Level 0 methods already used in NC3 and adds modern machine learning, such as deep neural networks, to detect more complex patterns, potentially critical for next-generation early warning systems. The key distinction of Level 1 systems is their ability to provide strong formal verification guarantees during operation.
- **Level 2: Information synthesis:** Like the public's use of ChatGPT as an enhanced search tool, this level performs information "reduction" tasks—sifting and summarizing vast data to improve analysts' situational awareness. Already cautiously valued in intelligence work, systems trained on diverse sources (e.g., imports, exports, news, government statements, satellite imagery) could generate integrated reports or flag patterns, streamlining efforts such as estimating tritium

gence (XAI): What We Know and What Is Left to Attain Trustworthy Artificial Intelligence," *Information Fusion* 99 (November 2023): 101805, <https://doi.org/10.1016/j.inffus.2023.101805>; Vijay Arya et al., "AI Explainability 360 Toolkit," in *CODS-CO-MAD '21: Proceedings of the 3rd ACM India Joint International Conference on Data Science & Management of Data* (Association for Computing Machinery, January 2021), 376–79, <https://doi.org/10.1145/3430984.3430987>; and Souradeep Dutta et al., "Sherlock—A Tool for Verification of Neural Network Feedback Systems: Demo Abstract," in *HSCC '19: Proceedings of the 22nd ACM International Conference on Hybrid Systems: Computation and Control* (Association for Computing Machinery, April 2019), 262–3.

62 Malkamu Mersha et al., "Explainable Artificial Intelligence: A Survey of Needs, Techniques, Applications, and Future Direction," *Neurocomputing* 599 (September 2024): 128111, <https://doi.org/10.1016/j.neucom.2024.128111>; Roy Lindelauf and Herwin Meerveld, "Building Trust in Military AI Starts with Opening the Black Box," *War on the Rocks*, August 12, 2025, <https://warontherocks.com/2025/08/building-trust-in-military-ai-starts-with-opening-the-black-box/>; and Konaev, Huang, and Chahel, "Trusted Partners."

63 "J3016_202104 – Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles," SAE International, last updated April, 29, 2021, https://www.sae.org/standards/content/j3016_202104/; and Philip Koopman, "SAE J3016 User Guide," Carnegie Mellon University, last updated September 4, 2021, <https://users.ece.cmu.edu/~koopman/j3016/>.

or plutonium production in North Korea's experimental light water reactor.⁶⁴ However, formal guarantees at this level (and higher) rely on arbitrary definitions of fairness and are therefore less reliable than the more concrete assurances possible with Level 1 systems.

- **Level 3: Strategy recommendations:** Given operator-specified information, the system generates and evaluates possible courses of action, specifically, an information “generation” task. The system must justify its recommendations with references to both the input data and its embedded values or reasoning. This contrasts with Level 2 systems, which only reduce information, producing traceable summaries that require far less justification.
- **Level 4: Human-in-the-loop automation:** This level integrates Levels 0–3 into a single system that independently gathers information and recommends actions based on the system's own situational awareness. Human approval and auditing remain essential to ensure that the pipeline from fact-gathering to recommended action stays sound.
- **Level 5: Full automation:** An AI-integrated, end-to-end automated launch system resembling a modernized Dead Hand (Perimeter) system remains one of the most controversial concepts in nuclear strategy. Debates over these systems frequently evoke imagery from classic science-fiction doomsday scenarios—*Dr. Strangelove* (1964), *WarGames* (1983), and *The Terminator* (1984)—and provoke strong moral discomfort among many observers. The United States continues to oppose such systems, reiterating in its 2022 Nuclear Posture Review its commitment to “in all cases . . . maintain a human ‘in the loop’ for all actions critical to informing and executing decisions by the President to initiate and terminate nuclear weapon employment,” a stance reaffirmed by General Anthony J. Cotton, commander of U.S. Strategic Command.⁶⁵ Though many experts argue for diplomatic engagement with other nuclear powers to explicitly ban these systems in future arms control agreements, some analysts advocate for exploring such technology as a response to the shifting deterrence landscape, specifically the unprecedented speed and stealth of hypersonic glide vehicle decapitation strikes.⁶⁶

64 For the cautious use of AI in intelligence, see Frank Bajak, “US Intelligence Agencies’ Embrace of Generative AI Is at Once Wary and Urgent,” AP, May 23, 2024, <https://apnews.com/article/us-intelligence-services-ai-models-9471e8c5703306eb-29f6c971b6923187>; and Patrick J. Park and Alexander Glaser, “Estimating Potential Tritium and Plutonium Production in North Korea’s Experimental Light Water Reactor,” *Science & Global Security* 32, no. 1–3 (2024): 68–82, <https://doi.org/10.1080/08929882.2024.2444751>.

65 U.S. Department of Defense, *2022 National Defense Strategy of The United States of America, Including the 2022 Nuclear Posture Review and the 2022 Missile Defense Review* (Washington, DC: U.S. Department of Defense, 2022), 22, <https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.PDF#page=58>. For General Cotton’s statement, see “NC3 Cybersecurity and Artificial Intelligence / Machine Learning Capabilities” Statement before the Subcommittee on Strategic Forces, Senate Armed Services Committee, 119th Cong., 1st sess., March 26, 2025 (statement of General Anthony J. Cotton, Commander, United States Strategic Command), https://www.armed-services.senate.gov/imo/media/doc/testimony_of_general_anthony_jcotton2.pdf#page=18. See also Anya L. Fink, “Defense Primer: Nuclear Command, Control, and Communications (NC3),” Congressional Research Service, August 15, 2025, <https://www.congress.gov/crs-product/IF11697>.

66 Noah Greene, “AI Nuclear Weapons Catastrophe Can Be Avoided,” Lawfare, March 1, 2023, <https://www.lawfaremedia.org/article/ai-nuclear-weapons-catastrophe-can-be-avoided>; Ashley Deeks, “Too Much Too Soon: China, the U.S., and Autonomy in Nuclear Command and Control,” Lawfare, December 4, 2023, <https://www.lawfaremedia.org/article/too-much-too-soon-china-the-u.s.-and-autonomy-in-nuclear-command-and-control>; Adam Lowther and Curtis McGiffin, “America Needs a ‘Dead Hand,’” War on the Rocks, August 16, 2019, <http://warontherocks.com/2019/08/america-needs-a-dead-hand/>; Adam Lowther and Curtis McGiffin, “America Needs a Dead Hand More than Ever,” War on the Rocks, March 28, 2024, <https://warontherocks.com/2024/03/america-needs-a-dead-hand-more-than-ever/>; and Matt Field, “Strangelove Redux: US Experts Propose Having AI Control Nuclear Weapons,” Bulletin of the Atomic Scientists, August 30, 2019, <https://thebulletin.org/2019/08/strangelove-redux-us-experts-propose-having-ai-control-nuclear-weapons/>.

THE RISKS WITHIN NC3 AUTOMATION-LEVEL TAXONOMY

- **Level 0: Classical signal processing:** While safety concerns remain real, AI-enabled systems represent classical technologies that have been part of the NC3 pipeline since its inception. As a result, they are widely deployed, established, and embedded within a long-standing and robust safety culture, making them the most thoroughly understood.
- **Level 1: Augmenting signal processing:** Although based on the statistical methods inherent in modern AI and machine learning, Level 1 systems can still achieve strong safety and operational guarantees through the application of appropriate formal verification techniques. As noted above, these methods require a safety engineer to develop a robust model and a clear set of formal requirements. Level 1 systems often fit neatly into these paradigms because they typically operate over numeric, measurable domains (e.g., sensor data, thresholds, safety margins). That said, neural network certification is still a new field of research, with open questions about how to best and most efficiently apply certification to specific use cases.
- **Levels 2–4:** As centaur systems, these levels all maintain a human in the loop, but at different degrees of automation. Since humans are susceptible to flattery, misinformation, and repetition, human judgment and machine output can blur together, making automation bias and its downstream effects the chief safety concerns. Higher levels imply more offloading to AI, which implies higher reliance and greater risks of automation bias.
- **Level 2: Information synthesis:** Automation bias risks distorting an operator’s situational awareness. The operator remains in full control of decisionmaking but is susceptible to skewed information.
- **Level 3: Strategy recommendations:** Automation bias risks distorting an operator’s recommended actions. The operator provides information but is now more susceptible to specific plans of action.
- **Level 4: Human-in-the-loop automation:** Combining the susceptibilities of Level 2–3, here, automation bias risks reducing operators to “mere rubber stamps.”

Without the purely numerical formal guarantees of Level 1 systems, realistic safety goals shift to explainability as a means to mitigate risks of AI bias (i.e., weighing evidence fairly) and accuracy (i.e., correctly interpreting data and avoiding fabricated or “hallucinated” facts). These concerns are much more open-ended than those found in Level 1. Given that the subjective nature of quantifying fairness, bias, and even accuracy is far from straightforward or outright impossible, the question of how to “best” reduce AI bias remains open. Moreover, the current lack of understanding and transparency makes it harder to best mitigate these negative effects; these challenges share much in common with public domain concerns over tools like ChatGPT. In addition to AI explainability, building meaningful trust and confidence will require organizational and social safeguards to curve the automation bias and bias AI feedback loop. Just as militaries rely on multiple analysts, red teaming, and competing perspectives to mitigate human bias, AI systems may need parallel or adversarial processes, independent auditing mechanisms, or structured model-training strategies to replicate this function. It is not clear how to best do this, so, at this time, confidence in safety-critical pipelines like NC3 rightfully remains low, but an extreme area of interest.

- **Level 5: Full automation:** Despite understandable arguments for operational advantages, Level 5 systems raise profound ethical and strategic concerns.⁶⁷ At this level, safety issues become

67 Joshua A. Schwartz and Michael C. Horowitz, “Out of the Loop Again: How Dangerous Is Weaponizing Automated Nuclear

both existential and out of users' hands: Any unexpected behavior could produce a "broken arrow" incident or trigger an unintended nuclear response.⁶⁸ Historical cautionary tales—such as the 1983 Soviet nuclear false alarm incident averted by Stanislav Petrov—underscore the danger of removing humans entirely from nuclear decisionmaking.⁶⁹ Even if meaningful trust and confidence were established in one's own automated system, breaking the AI-nuclear taboo would open a Pandora's box to existential risks from other such systems, especially ones that may not be built with the same rigor, safeguards, or oversight. This is the same logic underlying nonproliferation doctrine: The behavior of others, not just one's own restraint, defines the risk.⁷⁰ Perhaps the most effective way to mitigate Level 5 risks is not to "play" at all, hence the growing calls to engage other nuclear-armed states on the importance of maintaining human-in-the-loop safeguards and developing mutual AI confidence-building measures.⁷¹

CONCLUSION

AI is "worth the squeeze" for NC3 only insofar as it is possible to *engineer—not assume—trust*. The taxonomy presented here, together with the accompanying discussion of formal methods and AI explainability, is necessarily incomplete. It is intended as a practical starting point to help policymakers and strategists develop clearer terminology and better understandings of what the future of AI safety will look like. Understanding these concepts and their limitations will be key to developing prudent policies, constructive dialogue, and ultimately a safer trajectory for the heavily AI-enabled future that lies ahead.

Systems?," arXiv, arXiv:2505.00496, May 1, 2025, <https://doi.org/10.48550/arXiv.2505.00496>.

- 68 Lauren Kahn, "Mending the 'Broken Arrow': Confidence Building Measures at the AI-Nuclear Nexus," War on the Rocks, November 4, 2022, <https://warontherocks.com/2022/11/mending-the-broken-arrow-confidence-building-measures-at-the-ai-nuclear-nexus/>.
- 69 David Hoffman, *The Dead Hand: The Untold Story of the Cold War Arms Race and Its Dangerous Legacy* (New York: Anchor, 2009).
- 70 Thomas Schelling and Anne-Marie Slaughter, *Arms and Influence* (New Haven, CT: Yale University Press, 2020); and Brad Roberts, *The Case for U.S. Nuclear Weapons in the 21st Century* (Stanford, CA: Stanford University Press, 2016).
- 71 Fink, *Defense Primer*; Ioana Puscas, *Confidence-Building Measures for Artificial Intelligence: A Multilateral Perspective* (Geneva: UNIDIR, 2024), <https://unidir.org/publication/confidence-building-measures-for-artificial-intelligence-a-multilateral-perspective/>; Michael C. Horowitz, Lauren Kahn, and Casey Mahoney, "The Future of Military Applications of Artificial Intelligence: A Role for Confidence-Building Measures?," *Orbis* 64, no. 4 (2020): 528–43, <https://doi.org/10.1016/j.orbis.2020.08.003>; and Michael C. Horowitz and Lauren Kahn, "Leading in Artificial Intelligence Through Confidence Building Measures," *Washington Quarterly* 44, no. 4 (2021): 91–106, <https://doi.org/10.1080/0163660X.2021.2018794>.



Using Industry 4.0 and Cloud Manufacturing to Assist in Modernizing the Nuclear Security Enterprise

By William J. Peck¹

INTRODUCTION

Per the assessment in the National Nuclear Security Administration (NNSA)'s Enterprise Blueprint, the United States can no longer rely on current Nuclear Security Enterprise (NSE) capabilities to execute the nuclear modernization program of record and must overhaul decades-old production facilities and science and technology infrastructure to meet the growing threats of tomorrow.² As a goal, modernization is a high-level term that refers to NNSA investments surrounding both production and science and technology infrastructure to support the design, certification, and assessment of weapons. The first objective of modernization funding is targeted toward production research and facilities to ensure the health of the stockpile, while the second funding objective is meant to revolutionize and revitalize the scientific base to achieve new and necessary breakthroughs to balance out the dynamic and evolving threat environment.

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 - 2 National Nuclear Security Administration, *Enterprise Blueprint* (Washington, DC: Department of Energy, October 2024), https://www.energy.gov/sites/default/files/2024-10/NNSA%202024%20Enterprise%20Blueprint_508_compliant_10.21.24_update.pdf.

THE NUCLEAR SECURITY ENTERPRISE

The NSE is a collection of eight government-owned, contractor-operated sites throughout the country, as shown below:³

- Kansas City National Security Complex, Kansas City, MO
- Lawrence Livermore National Laboratory, Livermore, CA
- Los Alamos National Laboratory, Los Alamos, NM
- Nevada National Security Site, North Las Vegas, NV
- Pantex Plant, Amarillo, TX
- Sandia National Laboratory, Albuquerque, NM and Livermore, CA
- Savannah River Security Complex, Aiken, SC
- Y-12 National Security Complex, Oak Ridge, TN

The NSE comprises national security laboratories (Lawrence Livermore, Los Alamos, and Sandia) whose mission is to perform research to develop, sustain, and implement nuclear weapons design, simulation, modeling, and experimental capabilities and competencies.⁴ The four nuclear weapons production facilities (Kansas City, Pantex, Savannah River, and Y-12) are responsible for the production and assembly of materials and components of nuclear weapons. Lastly, the Nevada National Security Site conducts subcritical experiments while also maintaining the capability to resume explosive nuclear testing within 36 months.⁵ The NSE employs approximately 65,000 individuals operating in government-owned facilities across 40 million square feet of floor space and 2,000 square miles of land.⁶ In modernizing the NSE facilities, the NNSA must maintain and expand the current capabilities that produce systems for an effective and reliable nuclear deterrent, while also sustaining and developing key areas of expertise in the realm of workforce planning, technological maturation, and manufacturing operations.

THE CHALLENGES OF MODERNIZATION

Today, the external threats facing the United States are real and expanding. The 2022 Nuclear Posture Review noted that for the first time, the United States is facing two major nuclear powers as strategic competitors and potential adversaries, in addition to a deteriorating international security environment.⁷ As a result of the evolving threat landscape, the NNSA's scope of work and budget has increased as the agency attempts to both modernize nuclear weapons programs and recapitalize outdated production capabilities and associated infrastructure. In 2023, the Congressional Budget Office estimated that it will cost the NNSA over \$200 billion through 2032 to modernize the NSE

3 U.S. Government Accountability Office, *Fully Incorporating Practices for Agency Reform Would Benefit Enhanced Mission Delivery Initiative*, GAO-25-106675 (Washington, DC: Government Accountability Office, February 2025), <https://www.gao.gov/assets/gao-25-106675.pdf>.

4 National Nuclear Security Administration, *Fiscal Year 2024 Stockpile Stewardship and Management Plan* (Washington, DC: Department of Energy, November 2023), https://www.energy.gov/sites/default/files/2023-11/FY24SSMP_FINAL_NOVEMBER_2023_0.pdf.

5 Congressional Research Service, *The U.S. Nuclear Security Enterprise: Background and Possible Issues for Congress*, CRS Report No. R48194 (Washington, DC: Congressional Research Service, February 2025), <https://www.congress.gov/crs-product/R48194>.

6 National Nuclear Security Administration, *Enterprise Blueprint*.

7 U.S. Department of Defense, *2022 National Defense Strategy of the United States of America* (Washington, DC: Department of Defense, October 2022), <https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.pdf>.

and create a modern, safe, and reliable U.S. arsenal.⁸ In addition to modernizing, the NNSA must also sustain its normal obligations to the federal government regarding missions to research, develop, test, and evaluate the stockpile, while at the same time supporting nonproliferation and counterproliferation efforts as part of its global security mission. This task of both modernizing and executing mission objectives is a tremendous request for an administration that is experiencing many challenges.

One acute challenge is meeting workforce needs.⁹ The NNSA and NSE struggle to develop and maintain skilled and talented individuals in an industry with poor working conditions and fierce competition derived from the private sector. Difficulty managing the cost overruns and schedule delays of large construction projects represents another challenge, one that has led to an inability of the NNSA to meet its statutory and military requirements with regard to production deadlines. It is estimated that the total combined cost overrun of the NNSA's 18 major construction projects is \$2.1 billion, with a combined schedule delay of approximately 10 years.¹⁰ Some of these overruns and delays are derived from the NNSA's inability to accurately estimate the time needed to fully mature technologies, which has a run-on impact on the weapons acquisition and production process and the ability to mature newer technologies.¹¹ The acquisition and production of nuclear weapons also poses a challenge for the NNSA, as technologies and designs that are not well understood and are out of control in terms of tolerances and quality metrics continue to be placed in the field. This leads to significant waste of resources and time delays.

The NNSA is investing heavily in research and development (R&D) projects that develop and innovate technologies to improve current manufacturing processes and replace obsolete materials. In FY 2021, the NNSA spent approximately \$300 million on over 600 different R&D projects to support advanced manufacturing technologies as part of its new Advanced Manufacturing Development program.¹² In 2024, it was estimated that modernization would cost \$540 billion in acquisition costs through the decade and into the next.¹³ This figure balloons to \$1.5 trillion over the programmatic lifetime when one adds an extra \$430 billion for a new strategic delivery vehicle and another \$650 billion for weapons-related activities over the next 25 years.

This is in addition to site-specific laboratory-directed, plant-directed, and site-directed R&D. These efforts, however, may not be enough to bridge the advanced manufacturing gap. Diminishing manufacturing sources and infrastructure, a lack of skilled trade workers, and supply chain fragility are inhibiting both the sustainment and modernization of the NSE, and too little attention is being given to much-needed manufacturing innovations and design.¹⁴ Clearly, there is a need to continue exploring R&D options and alternatives within advanced manufacturing that will help the NSE modernize.

8 U.S. Government Accountability Office, *Fully Incorporating Practices for Agency Reform*.

9 Laura Werber et al., *Is the National Nuclear Enterprise Workforce Postured to Modernize the TRIAD?* (Santa Monica, CA: RAND Corporation, June 2022), https://www.rand.org/pubs/research_reports/RRA1227-1.html#citation; and William J. Peck, "Workforce Planning: A Review of Methodologies," *Annals of Operations Research* 352 (2025): 251–94, <https://link.springer.com/article/10.1007/s10479-025-06734-1>.

10 U.S. Government Accountability Office, *Fully Incorporating Practices for Agency Reform Would Benefit Enhanced Mission Delivery Initiative*.

11 U.S. Government Accountability Office, *Nuclear Weapons Acquisition Programs* (Washington, DC: Government Accountability Office, December 2024), <https://www.gao.gov/assets/gao-25-106048.pdf>.

12 U.S. Government Accountability Office, *NNSA Could Enhance Its Evaluations of Manufacturing-Related R&D Performance* (Washington, DC: Government Accountability Office, May 2022), <https://www.gao.gov/assets/gao-22-104506.pdf>.

13 Xiaodon Liang, "U.S. Nuclear Modernization Program," Arms Control Association, *Fact Sheets and Issue Briefs*, last reviewed August 2024, <https://www.armscontrol.org/factsheets/us-modernization-2024-update>.

14 Madelyn R. Creedon et al., *America's Strategic Posture Review: The Final Report of the Congressional Commission on the Strategic Posture of the United States* (Alexandria, VA: Institute for Defense Analyses, October 2023), <https://www.ida.org/-/media/feature/publications/a/am/americas-strategic-posture/strategic-posture-commission-report.ashx>.

The objective of this paper is to discuss how the application of advanced manufacturing technologies such as Industry 4.0 and cloud manufacturing may be one avenue to supplement how the NNSA directs investment as part of its scheme to modernize the NSE. Referring to the fourth industrial revolution, Industry 4.0 describes changes in information technology regarding manufacturing systems using automation, cyber-physical systems, AI, and cloud computing to create interconnected, efficient, and smart manufacturing systems.¹⁵ There are many avenues to implement Industry 4.0. One option is a centralized cloud manufacturing platform that represents a seamless and consistent method to share a variety of distributed manufacturing resources. These distributed manufacturing resources are described virtually within a digital platform and represent capabilities, capacities, and assets.¹⁶

The second section of this paper will offer a problem statement describing why modernization is crucial if the U.S.-led approach to international world order is to be maintained, followed by section three, which will cover background information describing advanced manufacturing technologies such as Industry 4.0 and cloud manufacturing to better ground the reader in these technical concepts. Section four offers an analysis of the technical steps that underpin the creation of a cloud manufacturing algorithm. These steps allow for the creation of a networked model where a CAD file of a part is imported and, upon execution in real time, produces estimates regarding cost and lead time for production at various vendors and machine shops. This is followed by a discussion of the potential implementation of cloud manufacturing at Los Alamos National Laboratory with regard to subtractive manufacturing operations and its benefits, and then the paper closes with concluding remarks.

PROBLEM STATEMENT

The United States faces a strategic challenge that requires urgent and fundamental action. Authoritarian regimes in Russia and China are threatening to disrupt and displace the U.S.-led international order with a surrogate system whose values are antithetical to those held by the United States and like-minded allies and partners worldwide.¹⁷ Soon, the nuclear capabilities of these two countries will exceed that of the United States, while the risk of conflict with them is growing. Within the last five years, China has significantly expanded an ongoing effort of nuclear modernization that has resulted in fielding more types and numbers of nuclear weapons than ever before.¹⁸ Among the nine nuclear-armed states, China is considered to have the fastest-growing arsenal. Similarly, Russia is nearing the end of decades-long effort to replace its strategic and nonstrategic nuclear-capable systems with newer versions. This modernization replaces its old Soviet-era facilities to hedge against the failure of its conventional forces in Ukraine.¹⁹

It comes at a time when the NSE is in urgent need of modernization, with the former NNSA administrator, Jill Hruby, describing half of the agency's facilities as "in poor or very poor condition."²⁰ The United States can no longer rely on facilities built before or near the start of the Cold War that

15 Heiner Lasi et al., "Industry 4.0," *Business & Information Systems Engineering* 6 (2014): 239–242, <https://doi.org/10.1007/s12599-014-0334-4>.

16 William J. Peck, *Network Considerations for a Cloud Manufacturing Platform* (University Park, PA: Pennsylvania State University, December 2023), <https://etda.libraries.psu.edu/catalog/22090wjp16>.

17 Creedon et al., *America's Strategic Posture Review*.

18 Hans M. Kristensen, Matt Korda, Eliana Johns, and MacKenzie Knight, "Chinese Nuclear Weapons, 2024," *Bulletin of Atomic Sciences* 80 (January 2024): 49–72, <https://doi.org/10.1080/00963402.2023.2295206>.

19 Hans M. Kristensen, Matt Korda, Eliana Johns, and MacKenzie Knight, "Russia Nuclear Weapons, 2024," *Bulletin of Atomic Sciences* 80 (May 2024): 118–145, <https://doi.org/10.1080/00963402.2024.2314437>.

20 Anya L. Fink, *The U.S. Nuclear Security Enterprise: Background and Possible Issues for Congress*, CRS Report No. R48194 (Washington, DC: Congressional Research Service, August 2025), <https://www.congress.gov/crs-product/R48194>.

have suffered from decades of neglect to meet the deterrence needs of today. At Los Alamos National Laboratory, approximately 30 percent of facilities are over 60 years old and approximately 56 percent are more than 50 years old, further highlighting the need for modernization.²¹ This is exacerbated by budgetary constraints, environmental protections, and regulatory challenges. Now more than ever, the nation needs the capability and capacity to develop, produce, and maintain nuclear weapons in a safe, secure, reliable, and modern manner to enable U.S. strategy.

INDUSTRY 4.0 AND CLOUD MANUFACTURING: BACKGROUND

Industry 4.0 posits a vision of modular and efficient manufacturing systems where advances in digital technologies are seamlessly merged to support automated manufacturing and production controls.²² Manufacturing systems would be transformed from traditionally centralized and hierarchical control modes to more flexible, decentralized systems that allow for more self-organization and faster decisionmaking.²³ As a result of this flexibility, enhanced control allows for further integration of value-added activities, information, and resources to further expand data exchange among heterogeneous workflow components using sensors, digitalization, and networking.²⁴ In the future, manufacturing systems will not be constrained by process hierarchy and will use digital sensors to control production lines and capture data analytics, increasing efficiency in terms of decisionmaking and information exchange among stakeholders.

The concept of Industry 4.0 evolved out of a desire to have highly connected resources throughout the entire manufacturing process so the flow information is spread by and available to all elements present on the shop floor.²⁵ This fundamentally changes the focus of manufacturing activities that historically had solely been characterized by physical and mechanical operations that produced a product that was then sold on the market. Now, manufacturing operations are characterized by information-intensive activities that utilize a variety of computers, sensors, and communications equipment in addition to automated and mechanical operations on materials.²⁶ In making this shift, enterprises are in the business of selling their resources, capacity, and capabilities as a service.

In selling a service, manufacturers are now transforming data from a design into a three-dimensional product.²⁷ Moving this beyond a single plant or enterprise, conceptually, it is possible to network together many factories and industries into a series of smart, virtual systems that synthesize specializations in terms of labor, resources, skill, and capabilities that help enable Industry 4.0.

In using cloud manufacturing as a methodology, it is possible to create a single, global platform shared across the internet that contains many distributed manufacturing resources that have been

21 Los Alamos National Laboratory, *2021 Campus Master Plan* (Los Alamos, CA: Los Alamos National Laboratory, January 2022), <https://lasg.org/documents/DOE-NNSA-Site-Plans/LANL/LANL-CMP-LA-UR-22-21424-FINAL.pdf>.

22 Jana Prochazkova, David Prochazka, and Jaromir Landa, "Sharp Feature Detection as a Useful Tool in Smart Manufacturing," *International Journal of Geo-Information* 9 (2020): 422, <https://doi.org/10.3390/ijgi9070422>.

23 Lasi et al., "Industry 4.0."

24 Robson Marinho da Silva, Fabricio Junqueira, Diolino J. Santos Filho, and Paulo E. Miyagi, "Control Architecture and Design Method of Reconfigurable Manufacturing Systems," *Control Engineering Practice* 49 (2016): 87–100, <https://doi.org/10.1016/j.conengprac.2016.01.009>.

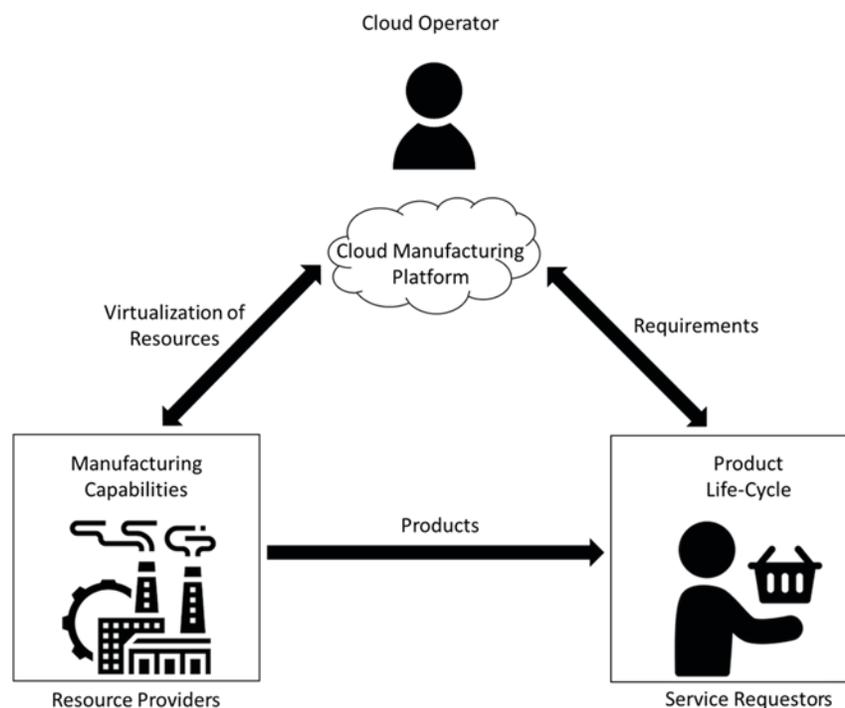
25 Oliver Cardin, William Derigent, and Damien Trentesaux, "Evolution of Holonic Control Architecture Towards Industry 4.0: A Short Overview," *IFAC-Papers OnLine* 51 (2018): 1243–1248, <https://doi.org/10.1016/j.ifacol.2018.08.420>.

26 Joel D. Goldhar and Mariann Jelinek, "Manufacturing as a Service Business: CIM in the 21st Century," *Computers in Industry* 14 (1990): 225–245, [https://doi.org/10.1016/0166-3615\(90\)90126-A](https://doi.org/10.1016/0166-3615(90)90126-A).

27 Joel D. Goldhar and Mariann Jelinek, "Computer Integrated Flexible Manufacturing: Organizational, Economic, and Strategic Implications," *INFORMS Journal on Applied Analytics* 15 (1985): 94–105, <https://doi.org/10.1287/inte.15.3.94>.

described virtually and are available for sale such that the needs of the customer are met in terms of schedule, cost, and quality.²⁸ Imagine a customer or service requestor who desires a part. Similarly, there also exists an enterprise or resource provider who produces the part in question using a variety of machines. The enterprise desires to reduce the overall idleness of its machine shop and lists its machining capabilities as virtual resources that can be bought on the cloud manufacturing marketplace by the service requestor who needs this part. In becoming a resource provider and virtually listing their resources on a cloud manufacturing platform, enterprises are motivated by information sharing within a market that will increase their utilization of machines, labor, material, and other inputs, while realizing reductions in overall floor idleness and general wastage and enabling more efficient use of energy and material.²⁹ Figure 1 depicts participants within a cloud manufacturing platform.

Figure 1: Interaction and Network Flow Between Resource Providers, Service Requestors, and the Cloud Operator Within a Cloud Manufacturing Platform



Source: William J. Peck, *Network Considerations for a Cloud Manufacturing Platform* (University Park, PA: Pennsylvania State University, December 2023), <http://etda.libraries.psu.edu/catalog/22090wjp16>.

The cloud manufacturing platform is managed and overseen by the cloud operator, who acts as an intermediary between the resource provider and the service requestor.³⁰ For the resource provider, manufacturing capabilities are encapsulated as virtual resources that are then advertised within

28 Robert Henzel and Georg Herzwurm, "Cloud Manufacturing: A State-of-the Art Survey of Current Issues," *Procedia CIRP* 72 (2018): 947–952, <https://doi.org/10.1016/j.procir.2018.03.055>.

29 F. Tao et al., "Cloud Manufacturing: A Computing and Service-Oriented Manufacturing Model," *Proceedings of the Institution of Mechanical Engineering, Part B: Journal of Engineering Manufacture* 225, no. 10 (2011): 1969–1976, <https://doi.org/10.1177/0954405411405575>.

30 J. Siderska and K. Mubarak, "Cloud Manufacturing Platform and Architecture Design," *Multidisciplinary Aspects of Production Design* 1 (2018): 673–680, <https://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-70551631-4c3c-4ab1-80b7-b3b9a023be0a>.

the cloud manufacturing platform. Meanwhile, service requestors are in the process of designing or obtaining a product that must meet a multitude of functional requirements that in many ways shape the manufacturing processes required for production. Interactions between the resource provider and the service requestor are facilitated on the cloud manufacturing platform, where the service requestor is seeking to fulfill a demand through the acquisition of services that the resource provider fulfills.³¹ In virtualizing and advertising their services on a cloud manufacturing platform, resource providers imply that there is excess capacity within their production processes that can be further utilized. Once advertised, service requestors can “shop” for manufacturers who meet their functional requirements through an automated matching algorithm.

The cloud manufacturing platform resembles a marketplace where services are advertised and sold. In this instance, service-related inputs reflect manufacturing capabilities inherent to resource providers and are granularly concerned with make, model, number, type of processing equipment, auxiliary software, available tools, technical documents, and finishing operations.³² Once virtualized, these descriptors help define the unique set of services that resource providers can fulfill. Next, the cloud operator allows many resource providers to list their manufacturing capabilities on the cloud manufacturing platform. Interactions between participants within the platform are facilitated by the cloud operator. Lastly, service requestors access the cloud manufacturing platform and upload a set of functional consumer requirements in order to identify a resource provider whose advertised manufacturing capabilities meet those requirements. The final output of this marketplace flow is a manufacturing service provided by a resource provider who can fulfill the demand required by the service requestor. In doing so, the resource provider is able to increase the overall utilization of their machines, which is their primary motivation for joining the cloud manufacturing marketplace.³³

ANALYSIS

Cloud manufacturing platforms are not new; they already exist within commercial spaces, having been previously developed by Xometry and Protolabs. In performing “manufacturing on demand,” cloud manufacturing platforms generally prompt a service requestor to upload a virtual representation of a part and specific attributes such as tolerances and material composition. Once complete, the service requestor submits the request and almost immediately receives a quote describing the lead time for production and the cost. How that virtual representation is transformed into a lead time and cost quote is the focus for this analysis section, which will discuss computer vision algorithms, vendor selection, and simulation modeling.

COMPUTER VISION ALGORITHMS

Broadly, computer vision algorithms teach machines how to interpret and analyze images in a similar fashion as the human brain. The initial virtual representation of a part is uploaded in a common file format used for 3D models, which the computer vision algorithm then assesses to identify a number of geometric features—commonly referred to as manufacturing features—that are distinct elements on

31 Dazhong Wu, J. Lane Thames, David W. Rosen, and Dirk Schaefer, “Towards a Cloud-Based Design and Manufacturing Paradigm: Looking Backward, Looking Forward,” *Proceedings of the ASME 2012 International Design Engineering Technical Conference & Computers and Information in Engineering Conference* (2012): 315–328, <https://doi.org/10.1115/DETC2012-70780>.

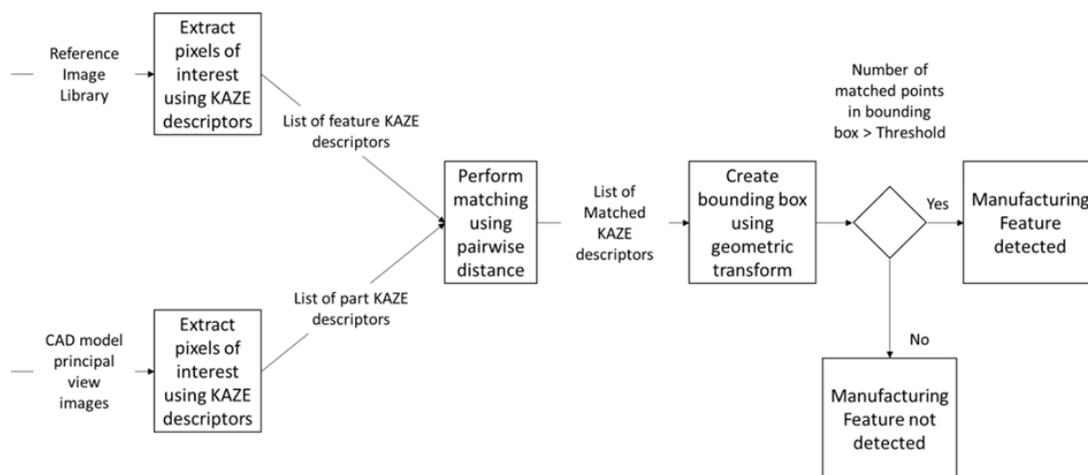
32 Julia Siderska and Khair S. Jadaan, “Cloud Manufacturing: A Service-Oriented Manufacturing Paradigm. A Review Paper,” *Engineering Management in Production and Services* 10 (2018): 22–31, <https://doi.org/10.1515/emj-2018-0002>.

33 Fanghua Ning et al., “The Architecture of Cloud Manufacturing and its Key Technologies Research,” *2011 IEEE International Conference on Cloud Computing and Intelligence Systems* (2011): 259–263, <https://doi.org/10.1109/CCIS.2011.6045071>.

parts, such as holes, pockets, curved sections, slots, or steps.³⁴ To do this, the computer vision algorithm will employ a feature detection algorithm such as scale-invariant feature transform (SIFT), speeded-up robust features (SURF), or KAZE (the Japanese word for wind) as examples of blob detection methods.³⁵ There are also other feature detection algorithms for corner detection and edge detection that may be more appropriate depending on the types of manufacturing features and part geometry.

Feature detection algorithms work by identifying and locating pixels of interest or keypoints. Generally, these keypoints are prominent and will have rich features at the pixel level that make them noticeable compared to their surroundings. The algorithm may also use a variety of scale-space smoothing techniques (which analyze features at different resolutions) to identify keypoints, generally using Gaussian smoothing.³⁶ Once the keypoints have been identified, they are compared against a reference image library, which contains a broad set of manufacturing features generally captured as images. Multiple keypoints from the virtual representation of a part are mapped to a reference image and a geometric transform is used to create a bounding box to encapsulate the manufacturing feature in question. If enough mapped keypoints are within the bounding box and the strength of the match is sufficiently high given a maximum distance parameter between a keypoint on the virtual representation projected over a keypoint on the reference image, then the algorithm will declare that the keypoints are describing a manufacturing feature. In doing so, the pairwise distance between the two keypoints (the first keypoint is projected over the second keypoint) is less than the maximum distance parameter. Once the computer vision algorithm has run to completion, it will output the number of manufacturing feature types located on the part in question. A high-level process flow of the computer algorithm is depicted in Figure 2, where KAZE is selected as the blob detection method to extract and detect pixels of interest or keypoints.

Figure 2: Illustration of a Computer Vision Algorithm Used to Extract Manufacturing Features



Source: Peck, *Network Considerations for a Cloud Manufacturing Platform*.

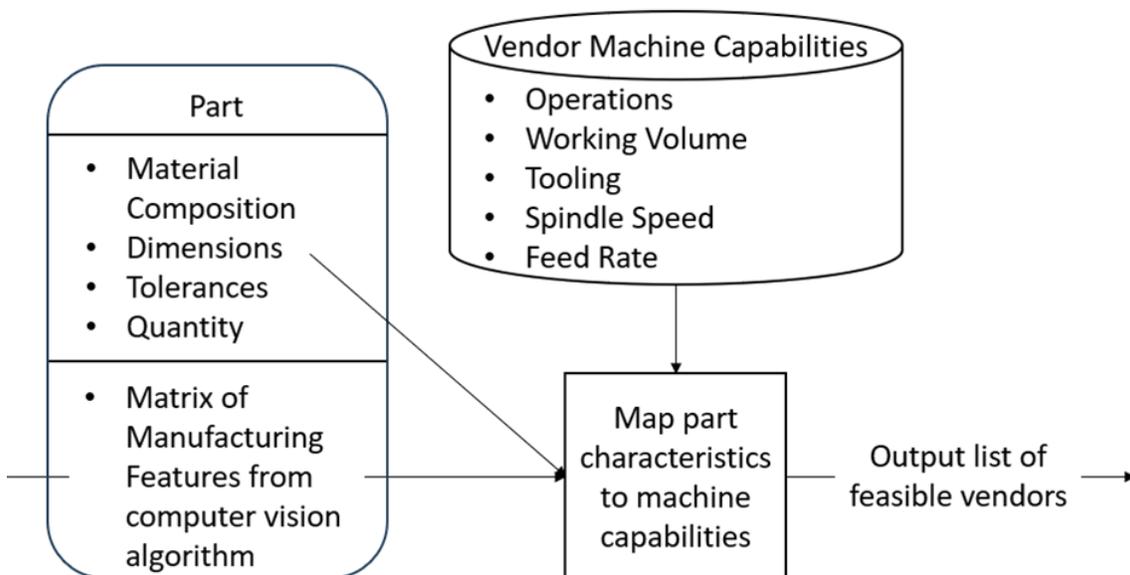
- 34 Several examples of these file formats include, but are not limited to STEP, STP, STL, PRT, and SLDPRT. J.J. Shah, "Assessment of Features Technology," *Computer-Aided Design* 23 (1991): 331–343, [https://doi.org/10.1016/0010-4485\(91\)90027-T](https://doi.org/10.1016/0010-4485(91)90027-T).
- 35 David G. Lowe, "Distinctive Image Features from Scale-Invariant Keypoints," *International Journal of Computer Vision* 60 (2004): 91–110, <https://link.springer.com/article/10.1023/B:VISI.0000029664.99615.94>; Herbert Bay, Andreas Ess, Tinne Tuytelaars, and Luc Van Gool, *Computer Vision and Image Understanding* 110 (2008): 346–359, <https://doi.org/10.1016/j.cviu.2007.09.014>; and Pablo Fernández Alcantarilla, Adrien Bartoli, and Andrew A. Davison, "KAZE Features," *European Conference on Computer Vision* (2012): 214–227, https://doi.org/10.1007/978-3-642-33783-3_16.
- 36 Think of scale-space smoothing techniques as a continual process to blur an image.

RESOURCE PROVIDER SELECTION

A key element of manufacturing features is selecting the specific manufacturing processes required to produce a given feature. For example, in subtractive manufacturing, holes generally require a drilling operation, and slots generally require a milling operation. More complex part geometries or unique material properties may require other techniques such as additive manufacturing. Knowing the manufacturing features that comprise a part makes it possible to map those features to manufacturing processes and thereby select potential resource providers based on their ability to produce the part given the processes they have on their shop floor. In conjunction with other part-related information such as material composition, dimensions, tolerances, and manufacturing features, it is possible to trim down a list of thousands of resource providers to a much smaller, feasible set that can produce the part.

Naturally, the cloud operator must have granular knowledge of the capabilities on a resource provider's shop floor to support this mapping. For manufacturing features, a knowledge of manufacturing processes is required. For part material composition, the tooling of manufacturing processes must be known. For dimensions of a part, the working volume for a specific machine must be known. Lastly, for part tolerances, the spindle speed and feed rate of a machine must be known. This is how information is mapped between individual parts and machines located on a resource provider's shop floor. If the provider can support the mapping and fulfill all requirements, it is considered feasible. If this is not the case and the mapping is not supported—for example, if a manufacturing process to produce a certain feature is missing—then the resource provider is considered not feasible. Once vendor selection is complete, the algorithm will output a set of feasible resource providers that are able to meet the requirements of the service provider. This entire process is depicted in Figure 3.

Figure 3: Mapping Manufacturing Features and Other Part Specifics to Vendor Machine Capabilities



Source: Peck, *Network Considerations for a Cloud Manufacturing Platform*.

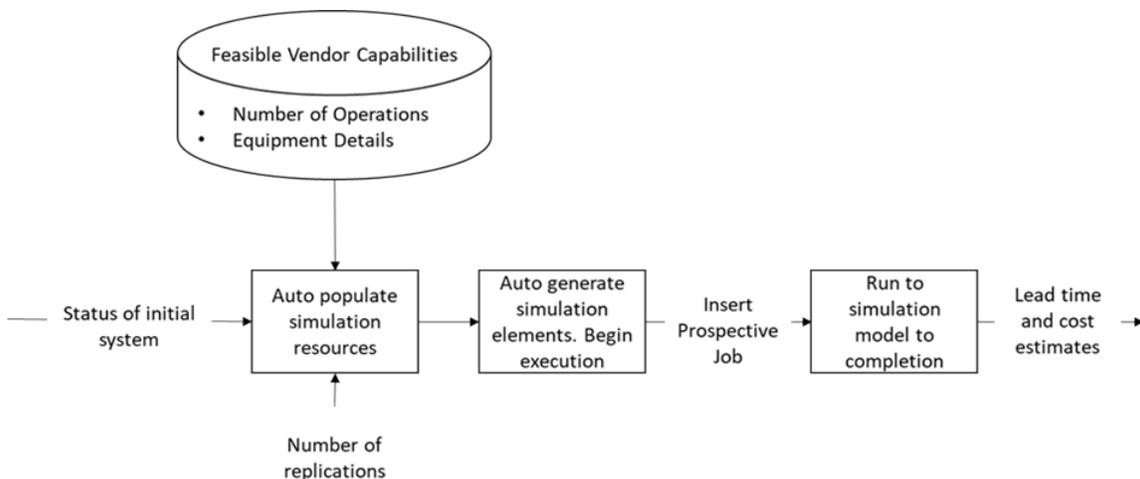
SIMULATING LEAD TIME AND COST

As shown in Figure 4, the cloud manufacturing platform first represents the manufacturing process of the part in question as a series of discrete events that must be sequentially performed. It then selects a computer modeling and simulation methodology (such as discrete-event simulation) to estimate the lead time and cost required to produce a specific part given the necessary routing through a series of manufacturing processes as specified by the number and types of manufacturing features.

Additionally, given granular knowledge of capabilities on a resource provider's shop floor—as provided by the feasible vendor capabilities database—a database of processing times dependent on the type of manufacturing process, material composition, and tooling is created to assist in the execution of the computer simulation model. This knowledge should be general in nature so that it can be widely applied to many cases and represents a consensus among experts regarding the approximate time a tool of particular parameters can perform work on a specific material composition. In the case of subtractive manufacturing, the hierarchy of operations is also used to inform part routing through various manufacturing processes. For cost, the raw material cost, time on machines, labor cost, and overhead is used to provide an estimate. The cloud operator may also wish to include their own overhead as a percentage of the total cost to help support platform operations.

For each feasible resource provider, the number of machines on the shop floor and the manufacturing processes a machine can perform is known by the cloud manufacturing platform. In this way, the modeling of the shop floor is automatically achieved using an object-oriented programming language that also routes the part among various machines and manufacturing processes. The model is automatically created and executed with appropriate confidence intervals and input-uncertainty corrections performed that ultimately deliver the lead time and cost quote to produce the part. Vigorous verification of the processing time database and cost accounting is required to ensure the accuracy of these estimates within the quote. Finally, upon completion of the simulation, the cloud manufacturing algorithm produces a list of feasible resource providers' lead time, and cost estimates for each. This allows the service requestor to select the most appropriate option for their scenario. It is likely that lead time and cost estimates will vary given the utilization and scheduling load per resource provider. The service requestor will likely choose between receiving the part sooner and paying a higher premium or receiving the part later and paying a lower premium.

Figure 4: Simulating Lead Time and Cost Estimates



Source: Peck, *Network Considerations for a Cloud Manufacturing Platform*.

DISCUSSION

The NNSA faces acquisition and production hurdles. Better understanding the capabilities of the various machine shops within the NSE through the implementation of a cloud manufacturing platform as part of modernization will help the NNSA formally and comprehensively document acquisition programs.³⁷ This in turn will allow the NNSA to better assess the maturity of critical technologies to ensure that their implementation with regard to acquisition and production goes according to plan to avoid cost overruns and schedule delays, while maximizing performance of these technologies. The choice of machine shops is strategic, as the national laboratories and production facilities are composed of a multitude of such shops that collectively support various NNSA missions. By selecting these shops—the smallest common denominator in production—the ability to effect the most change through the implementation of a cloud manufacturing platform is unlocked.

Los Alamos National Laboratory (LANL) is a prime candidate to develop and implement a cloud manufacturing platform due to the large scale and complexity of production and the subsequent demand that those missions place on machine shops scattered throughout the campus at various technical areas to support both weapons and laboratory fabrication needs. LANL is selected as a proof-of-concept candidate due to the several product lines it owns and produces and the volume of on-campus machine shops and other engineering services that ultimately support those lines. This proof-of-concept idea should be examined on a trial-run basis over two years (after the platform has been fully developed and implemented) to measure the amount of cost and schedule savings. If significant and noteworthy, the NNSA should consider extending the platform to the entire complex to create a cohesive manufacturing capabilities network.

To begin implementing a cloud manufacturing platform, LANL will need to focus its efforts on a specific manufacturing operation, such as additive or subtractive manufacturing, to make the task of implementation more palatable. Once a specific type of operation has been selected, the laboratory will need to identify all machines that can perform it. For example, if subtractive manufacturing is selected as the type of manufacturing operation, LANL will need to engage every machine located within the campus to identify the make and model of all subtractive manufacturing machines. It is also possible that for the unique case of subtractive manufacturing, certain machines will be capable of performing more than one type of this process—for example, both milling and drilling operations.

In identifying the make and model of every machine capable of subtractive manufacturing operations on an industrial scale, more granular information will be needed to support differentiation between machines. For the subtractive manufacturing case, this will include information related to the working volume of the machines, feeds and speeds of the machines, the number of operations that a machine can support, and the associated tooling that each machine uses. Focusing on the different types of tools available, every flavor of subtractive manufacturing operation will have different tools with different associated parameters. As an example, a tool used in milling operations will contain flutes, but this is not the case for a tool used for turning operations on a lathe. Regardless, more granular information regarding tool- and operation-specific characteristics should be gathered, such as wear resistance of the tool, tool hardness, temperature stability of the tool, the number of flutes, and the cutting edge of the tool.

37 U.S. Government Accountability Office, *Nuclear Weapons Acquisition Programs*.

As this information is being captured, it will need to be virtualized and stored within a database for use within the cloud manufacturing platform. This database of subtractive manufacturing capabilities will allow the resource provider and service requestor in Figure 1 to communicate.

This database is akin to the “vendor machine capabilities” database shown as an oval in Figures 4 and 5. Every possible piece of information that is used to differentiate one piece of machinery from another within a machine shop should be captured to achieve the most granular and specific differences in functionality, capability, and capacity. In addition to creating a database of capabilities, LANL should be simultaneously creating the networked algorithm as described in above and in Figures 3, 4, and 5 that will automatically extract manufacturing features, identify a list of feasible machine shops, and automatically generate simulation models to estimate cost and lead time per each machine shop.

Once the database and networked algorithm are complete, the cloud manufacturing platform can be rolled out to the entire laboratory for use in identifying the most feasible machine shop to achieve piece part production. From a larger and more analytical approach, once the cloud manufacturing platform is active and operating, LANL will be able to better consider its subtractive manufacturing capabilities to identify areas of opportunity—specifically, where new manufacturing capabilities can be stood up to support more complex and nuanced manufacturing tasks, the identification of bottleneck operations that slow down production and inhibit mission readiness and throughput, or the accounting of materials and resources that add extra cost due to scarcity or lack of research. In implementing and overseeing this platform, LANL can gain insight regarding new and emerging manufacturing technologies, potential processes and operations that need to be modernized, and the identification of scarce materials and resources to promote better sourcing. The implementation of such a platform will not only economize and streamline piece production but enable a holistic understanding of the manufacturing capabilities available and their deficiencies to promote further enhancements and improvements.

That said, security risks pose a serious hurdle to the implementation of a cloud manufacturing platform. Properly securing a manufacturing platform located on the cloud so that it is possible to transfer the entire catalogue of parts comprising U.S. nuclear weapons among sites would present a significant challenge. Classifications and compartmentalization would also need to be managed to ensure that only authorized individuals have the appropriate access. Additionally, accounting for change control processes as designs undergo revisions and mature would be complex, as would ensuring that machine shops have access to the “most recent” version of the CAD file to allow for production.

CONCLUSION

The NNSA is undertaking a rapid modernization of the NSE to rebuild and establish a new era of production and scientific infrastructure that underpins the nuclear stockpile and provides confidence in domestic deterrence. This modernization investment is crucial to ensure the U.S.-led international order is maintained as challenges emerge from Russia and China, including growing adversarial action and nuclear stockpiles, capabilities, and modernized production facilities. Other than a complete and total overhaul, there is no single solution methodology that will facilitate this modernization.

The NNSA Blueprint outlines many areas where investment is being directed, one of which is advanced manufacturing technologies.³⁸ This paper presented an overview of one such technology, cloud manufacturing. It explained the technical details of the implementation of a cloud manufacturing platform to support advanced manufacturing investment strategies. It then discussed the potential creation and implementation of a cloud manufacturing platform at Los Alamos National Laboratory, focusing on subtractive manufacturing operations. In creating such a platform, LANL could streamline and economize piece part production at its machine shops to better support the overarching manufacturing missions crucial to deterrence credibility. Additionally, implementation of a cloud manufacturing platform and its associated operation would allow LANL to achieve a better understanding of its manufacturing capabilities and to analyze areas of improvement as they pertain to new manufacturing capabilities, bottleneck operations, and resource and material sourcing. All of this contributes to a more efficient, productive, and agile manufacturing environment that supports and exceeds the overall goals of modernization as outlined by the NNSA.

38 National Nuclear Security Administration, *Enterprise Blueprint*.



Sailing Through the Sightless Sense

The Psychology of Algorithmic Nuclear Deterrence and Human-Machine Relations

By Ariel (Phantitra) Phuphaphantakarn¹

Successful nuclear deterrence ultimately depends upon the human mind. Fear, rivalry, and ambition for both nuclear action and reaction existed long before the Hiroshima bombing. Yet society persists in a delicate bargaining, hoping that Nagasaki will be the last to have seen the mushroom cloud. However, this precarious interaction between nuclear-armed states' ambivalent signals of peace now confronts one of the most unpredictable strategic factors of the twenty-first century—artificial intelligence (AI). As a catalyst and an enabler, AI entered the landscape as a means of improving machine systems and functions, consequently prompting conversations about its implications, especially in high-stakes realms such as nuclear deterrence.

But where do the human mind and human agency fit into the equation, besides having to constantly defend their contributions to the game? Is it truly possible to ensure effective nuclear deterrence in an era when AI-enabled machine systems increasingly challenge not merely human intelligence writ large, but the mind's cognitive processes? While much attention is given to the idea of “human control”—however vaguely that is defined, if at all—as a way to coexist with AI and reap the benefits of both human and artificial intelligences, analysts often forget that integrating AI into cognitively burdensome tasks, such as perceiving enemy intentions, requires careful thought about how human cognition, comprehension, and perception are affected when AI becomes part of the team.

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This paper suggests that the key to ensuring effective nuclear deterrence in an increasingly AI-integrated world lies in examining the elements of human-machine relations in AI-integrated nuclear deterrence—specifically in the context of AI-enhanced situational awareness—and the role those interactions play in increasing, or decreasing, risks of deterrence failure, such as misperception, misinterpretation, or unwanted escalation. Focusing on the human mind behind the deterrence equation will also help steer existing debates on the dichotomy between humans and machines, as well as decisionmaking authority in nuclear deterrence, in a more productive direction.

In order to explore the psychology of the mind—particularly the roles of perception, comprehension, and projection—underlying nuclear deterrence in an algorithmic age, this paper identifies three categories of potential risks of deterrence failure when AI negatively influences human judgment and cognitive processes: illusion risks, algorithmic anxiety risks, and scopic regime risks.² The progressive concepts of human-machine interaction, integration, and teaming, along with the role of human agency, are also discussed as potential approaches, alongside the “SIGHT” policy framework, which is designed to provide a pathway for navigating this critical strategic question.

THE PSYCHOLOGY OF (ALGORITHMIC) NUCLEAR DETERRENCE: SITUATIONAL AWARENESS

What is the psychology of, or the mindset driving, nuclear deterrence? Is it the nation’s ambition pushing for nuclear deterrence, or the result of scientists’ anxiety, or even the consequence of the “nuke” threat made by the U.S. president? For the purposes of this research, the ability to perceive, understand, and anticipate the circumstances in which one finds themselves (i.e., situational awareness) will serve as the framework through which the psychology of nuclear deterrence is explored.³ On the military front, situational awareness is not only a highly focused area for AI applications, but also a key domain for debates on human contributions to advancing strategic advantages.

In both theory and practice, situational awareness is critical, especially in the context of warfare and strategic decisionmaking. In order to attain situational awareness, one must not only have an understanding (perception) of the environment but also comprehend the larger situation and be able to speculate what may happen next. This particular dynamic is captured by Endsley’s three-tier model of situational awareness, commonly cited as the key cognitive model for constructing and understanding situational awareness.⁴ The model states that situational awareness consists of three interconnected levels: **perception** (noticing key elements in the environment), **comprehension** (the synthesis of the recognized data to form an understanding), and **projection** (forecasting future conditions based on current and past data).

2 It is worth noting that there are existing literatures arguing for the potential benefits of AI integration in nuclear weapons systems; however, this paper focuses on the risks associated with such integration and the questions that should be asked to ensure deterrence effectiveness without becoming mired in debates over human versus machine.

3 Understanding situational awareness, including its definitions, models, and theoretical debates, constitutes a domain of study in its own right. See Mica R. Endsley, “Situation Awareness Misconceptions and Misunderstandings,” *Journal of Cognitive Engineering and Decision Making* 9, no. 1 (2015): 4–32, <https://doi.org/10.1177/1555343415572631>.

4 Mica R. Endsley, “Toward a Theory of Situation Awareness in Dynamic Systems,” *Human Factors: The Journal of the Human Factors and Ergonomics Society* 37, no. 1 (March 1995): 32–64, <https://doi.org/10.1518/001872095779049543>. See, for example, David John Bryant et al., “Modeling Situation Awareness in an Organizational Context: Military Command and Control,” in *A Cognitive Approach to Situation Awareness: Theory and Application*, ed. Simon Banbury (London: Routledge, 2017), 13.

For the purposes of this research, Endsley's model is well-suited to examining human-machine interactions in the context of algorithmic nuclear deterrence, or the art of deterrence strategy in the AI age. Endsley's three levels—perception, comprehension, and projection—comprehensively capture the psychological processes, especially those required in the realm of strategic decisionmaking, which have long been tasked to human intelligence and are now introduced to machines through AI.⁵

The quest to understand the mind in the context of international relations has long engaged many leading scholars. This is because strategy, including nuclear deterrence and the use of force, relies heavily on human perceptions of adversaries and the decisions made based on those perceptions. As the United States enters an era shaped by AI-enabled technology, it becomes increasingly important to examine how AI affects human cognition in this climate of uncertainty.

AN ALGORITHMIC PERCEPTION: PROMISES OF AI-ENHANCED SITUATIONAL AWARENESS

Information is a key asset for military decisionmaking. Thus, as one of the most powerful and efficient information processing (and acquisition) tools, practitioners and theorists task AI-enabled technologies with missions to support deterrence strategy and operations, including the decision support system.⁶ The rationale behind AI application in the military often revolves around increasing the efficiency of combat activities, especially in the areas where human capacity is still limited or can be improved. These applications include, but are not limited to, intelligence acquisition and processing, military logistics, and early warning systems. Enhancing commanders' capacity to make tactical and strategic decisions by enabling leaders to be better informed faster is frequently cited as the primary objective of such efforts, along with seeking overall military advantages for the mission.⁷

AI supports all three levels of situational awareness through its ability to aid intelligence acquisition, integrate information into analysis systems, and support the OODA loop (observe, orient, decide, and act), thus influencing perception, comprehension, and projection in a variety of ways.⁸ AI's integration into nuclear systems ranges from early warning systems and intelligence, surveillance, and reconnaissance (ISR) to the command and control architecture.⁹ Already, operators work side by side with either the visual data provided by drones thousands of miles away or the computer programs that help support intelligence analysts interpreting the acquired data. Strategic decisionmakers are surrounded by enormous amounts of information and must be mindful of analyses, including consideration of whether recommendations are produced by humans or machines.¹⁰ Although more information is often believed to be beneficial by both practitioners and theorists worldwide, users of that information must recognize the psychological obstacles, including burdens and biases, that can grow alongside such vast data.

5 Robert Jervis, *The Meaning of the Nuclear Revolution* (New York: Cornell University Press, 1989), 148–73.

6 U.S. Department of Defense, *Summary of the Joint All-Domain Command and Control (JADC2) Strategy* (Washington, DC: U.S. Department of Defense, 2022), <https://media.defense.gov/2022/Mar/17/2002958406/-1/-1/1/SUMMARY-OF-THE-JOINT-ALL-DOMAIN-COMMAND-AND-CONTROL-STRATEGY.PDF>. The decision support system often also needs assistance; see Eduardo Cardenas, *Decision Support Systems for Command and Control: The Need for a Commander's Strategic Decision Aid* (Carlisle, PA: U.S. Army War College, 1997), <https://apps.dtic.mil/sti/tr/pdf/ADA326935.pdf>.

7 Frank Sauer, "The Military Rationale for AI," in *Armament, Arms Control and Artificial Intelligence*, eds. Thomas Reinhold and Niklas Schörnig (Cham, Switzerland: Springer Cham, 2022): 27–38, https://doi.org/10.1007/978-3-031-11043-6_3.

8 Michael C. Horowitz and Erik Lin-Greenberg, "Algorithms and Influence: Artificial Intelligence and Crisis Decision-Making," *International Studies Quarterly* 66, no. 4 (2022), <https://doi.org/10.1093/isq/sqac069>.

9 Vladislav Chernavskikh, "Nuclear Weapons and Artificial Intelligence: Technological Promises and Practical Realities," Stockholm International Peace Research Institute, SIPRI Background Paper, September 2024, <https://doi.org/10.55163/vbqx6088>.

10 Horowitz and Lin-Greenberg, "Algorithms and Influence," 1–12.

The fact that AI is supporting devices and technologies that help gather intelligence information implies that any subsequent perception is directly dependent on the effectiveness of the AI-enabled systems. While concerns about system malfunctions, biases, and hallucinations are well-versed across disciplines, AI, as both an analytical and data-processing tool, carries the potential to influence the minds of its users on deeper levels, prompting them to question their own comprehension and projection of events. While questioning is not inherently a bad thing, during moments of crisis it can be dangerous, especially when decisionmakers may already have the correct assessment. Understanding the human mind, especially in relation to the arrival of AI-enabled systems that may alter situational awareness, must remain central to any strategic planning.

WHO ARE THE HUMANS, AND WHERE ARE THE MACHINES?

Depending on the context, AI applications can comprise sources of information, tools for skill acquisition, or simply computer programs that help design a new gym routine. Given the human-centered focus of this research, this study prioritizes the role of humans in relation to AI. This paper proposes that, in the context of nuclear deterrence and military operations, human-machine relationships can be conceptualized as falling under three, sometimes overlapping categories.¹¹

- **The Applicators:** This group may also be referred to as the users, consumers, or, in a military context, operators or analysts. The applicators are those who use or apply AI in their daily lives and work for various purposes and in various contexts. In the realm of military operations and deterrence, these are the officers responsible not only for ensuring that systems function properly as per their respective missions, but also for applying the information acquired in analytical and operational contexts. For applicators, situational awareness is centered on perception and comprehension, depending on the nature of their tasks. One might imagine, for instance, Air Force officers overseeing intelligence collection, ensuring that the data is gathered, interpreted, and applied in alignment with their mission objectives.
- **The Designers:** This group may also be referred to as the engineers, developers, or researchers. Designers are responsible for creating systems that are both fit for their intended purposes and resilient against any biases, hallucinations, and technical failures that could lead to misperception or miscalculation and, ultimately, the failure of deterrence. For designers, situational awareness often appears either as data points or as the mission objective. While their direct engagement with situational awareness may be less immediate than that of applicators (or navigators, as discussed below), the designer's role is nonetheless foundational. The systems they design underpin all three levels of situational awareness and can significantly shape the psychological dynamics of algorithmic nuclear deterrence.
- **The Navigators:** This group may also be described as those in the realm of strategic leadership or command. Navigators are those entrusted with decisionmaking authority; they might employ AI to enhance the quality of their judgments along with the speed. Such applications may range from systems that support data acquisition and analysis to those that enable pattern recognition and projection. Although navigators may draw on AI at any stage of situational awareness acquisition or application, the nature of their responsibilities makes it most likely that they will rely on tools that directly support decisionmaking processes. Similar to the applicators, if the systems that navigators employ are ineffective, they risk making decisions based on

11 These categories primarily emphasize humans and their roles in relation to machines, though the reciprocal understanding of different roles and functions of the machines for humans is equally important.

misinformation, potentially resulting in misperception, miscalculation, or escalation, though the consequences at this level of authority are likely to be far more severe than for applicators. For navigators, perception is not merely about literal environmental objects (as is the case for applicators) but also includes potential signals, the estimated perceptions of adversaries, and any AI-related threat perception in general.

As this research examines the influences of AI on the humans involved, it is worth noting three possible means by which the machine might impact human action:

1. The information provided directly by the system, which can affect human judgment;
2. The system's ability to assist with information or attacks on relevant platforms, which may lead to misperception, miscommunication, and stress, along with other related errors; and
3. The mere presence of the system, which can influence the expectations, speculations, and anxiety of those involved in the equation.

AI remains a technology without full verification or credibility demonstrated in practice. As a result, assessing the potential impact and determining the appropriate level of concern involves a combination of imagination based on available data as well as operators' personal experiences and beliefs.

Understanding the different roles of humans in the nuclear deterrence realm in relation to AI reveals how and what can go wrong when considering the human element in the equation of algorithmic nuclear deterrence and the psychology that influences its direction, including risks and effectiveness. For instance, the implications for the operators may relate directly to the system's efficiency and effectiveness, while the concern for strategists may lie in the perception of an adversary's AI strategy, understanding the system's military application, or in their own platform's vulnerabilities. Each human role, whether applying or utilizing AI, shapes the overall effectiveness and risks of nuclear deterrence, especially in the algorithmic age.

ALGORITHMIC NUCLEAR DETERRENCE RISKS

AI introduces a wide range of risks into the domain of nuclear deterrence. Focusing specifically on those risks linked to situational awareness and the dynamics of human-machine interaction, this study identified three areas of nuclear deterrence risks:

1. Illusion risks—the risk that a system failure could mislead humans;
2. Scopic regime risks—the risk that an overwhelming amount of data may actually cause operators to lose situational awareness amid the abundance of AI-supported information; and
3. Algorithmic anxiety risks—the risk that an AI system, whether in its presence or application, jeopardizes human judgment by inducing stress and anxiety.

Classic literature identifies misperception, miscalculation, and miscommunication as major sources of deterrence failure, often arising when situations or an adversary's intentions are misunderstood or misjudged, leading to incorrect decisions being made. The information provided by the system, or even perceptions of the system's presence, can shape how humans interpret the behavior of rivals. This raises several complex questions. For instance, how might systems, including by their mere presence, application, and potential failures, influence human judgment and decisionmaking? More specifically for the question examined here, how might the involvement of machines undermine deterrence that would otherwise have been effective if the humans in the equation were not adversely affected?

For effective decisionmaking, the humans behind the machine must trust the system when they should (i.e., when the machine is effective, and their own judgments may not be completely correct), and not trust the machine when they should not (i.e., when the machine is ineffective, and their judgment is already correct).¹² In this regard, the challenges are on two fronts. First, the machines must function effectively and be resilient against biases, hallucinations, and any potential technical failures. Second, humans need to not only have the right judgment but also know when to trust the machine (or not), either by identifying system failures or inaccuracies, or by having enough confidence in their own knowledge and judgement to decide how much input from the machine should be taken into consideration, if at all. These two fundamental challenges highlight the complexity of the strategic questions in this new algorithmic age and are reflected in the three key risks identified here.¹³

ILLUSION RISKS: MACHINES MISLEADING PERCEPTION

As mentioned, the information provided by AI systems can shape how humans interpret the behavior of rivals, making system effectiveness crucial to the perceptions of operators, analysts, and, ultimately, decisionmakers. AI-enhanced situational awareness, with applications ranging from unmanned systems to early warning and intelligence analysis support, can influence the perception, comprehension, and projection of the humans involved in nuclear deterrence. In this context, illusions affecting human judgment may arise from various types of system failures, and manipulation and deception by these systems can take many forms, including selective presentation of information, misinterpretation of data, and system hallucinations.

AI systems are designed to reach their goals via the most effective and efficient route, but what if that route includes lying or twisting the truth? This aspect of AI design is part of the reason why hallucinations—where AI systems generate outputs that appear confident and authoritative but are factually incorrect or entirely fabricated—occur. Such hallucinations may arise from fundamental limitations of the system itself, including how it was designed, how it learns, or how it processes information.¹⁴

Accounting for the risk of hallucinations is further complicated by the so-called black box problem, in which the processes of algorithmic logic and how AI arrives at its outputs remain incompletely understood.¹⁵

Additionally, the system's potential contribution to misperception is also part of the illusion risks. For example, adversaries could intentionally deepfake information or attacks on the system to provide misinformation and create illusions that can lead to user misperception. Such a problem might be

12 The ideal scenario also includes cases where both human judgment is correct and the machine is effective. This implies coordination and the application of AI to further advance the mission's goals. Equally important is to avoid situations where both human judgment is flawed and the machine is ineffective, as this would almost certainly lead to mission failure. In this context, the terms "right" and "wrong" refer to decisions that either advance the goal in a positive direction or hinder it in a negative one.

13 It is important to note that each of the following identified risks is, by nature, intertwined with the others, as they are all connected to the human mind in the decisionmaking process. For instance, an overwhelming amount of information received in a short period of time, including potential machine deception, might be the very reason for heightened stress and anxiety in the decisionmaker, leading them to believe that the (aggressive) decision must be made immediately.

14 Teodor Frunzeti, Tiberius Tomoiagă, and Liviu Coșereanu, "Effects of AI Hallucinations on Military Systems," *Annals Academy of Romanian Scientists Series on Military Sciences* 17, no. 2 (2025): 13–37, <https://doi.org/10.56082/annalsarscimilit.2025.2.13>.

15 Sara Goudarzi, "Why Nobody Can See inside AI's Black Box," *Bulletin of the Atomic Scientists*, January 27, 2025, <https://thebulletin.org/2025/01/why-nobody-can-see-inside-ais-black-box/>.

prevented by operators who are equipped with the skills and knowledge to identify such deception; however, this heavily depends on and is influenced by the cognitive capacities of the humans involved.

THE SCOPIC REGIME PROBLEM: MACHINES OVERWHELMING THE MINDS

If the drones are doing the seeing, do the operators truly have situational awareness?

Vision is crucial for perception; the greater the ability to observe, the higher the chance of victory. In the context of AI and military applications, the concept of the scopic regime describes the visual configurations and practices of drones' perception of targets and the battlefield environment, ranging from the drone's optical perspective on targets to how drones are understood and situated within the institutions that employ them.¹⁶ This understanding highlights the increasing centrality of visual information in modern warfare and is arguably cheered on by the military's all-seeing eye preference.

In this regard, the concept of the scopic regime highlights a key aspect of rational deterrence theory: the belief that having more information leads to better decisionmaking and stronger deterrence. As the demand for drone surveillance and visual intelligence grows, decisionmaking has become increasingly reliant on their data and outputs, especially in the context of situational awareness. However, when considering the human element behind the machine, concerns remain, including information complexity and potential cognitive burden.¹⁷ In addition, there are the possible implications of human operators' de-visualization—that is, if the drones are doing the “seeing,” particularly as they have capabilities beyond human visual capacity, what does this mean for actual vision and, therefore, the real situational awareness of people in the realm of decisionmaking?¹⁸ De-visualization is an important question considering the possibility of cognitive biases and limitations when large amounts of information flood in at the same time. How can the quality of decisions be ensured so that they are not influenced by biases or misled into misinterpretation?

On a philosophical note, this raises questions about anything that comes through AI systems before it reaches the operator. How should the data be managed? How should one interact with the system, and in turn, how does it influence a user's logical thinking and task execution? Is it even possible to know what questions to ask when facing such obstacles? Can the sources of difficulties and the resources required to address them be fully identified? It must be noted that the purpose here is not to advocate for reducing information, but rather to emphasize the need for management strategies that help operators and decisionmakers navigate potential information overload and be mindful of possible obstacles so that, at an organizational level, the best approaches can be adopted to manage such uncertainty.

ALGORITHMIC ANXIETY RISKS: MINDS PROJECTING MACHINE-INDUCED FEAR

The pressured mind makes panicked decisions. In classic political psychology and international relations literature, the relationship between stress and the quality of decisionmaking is a fundamental concept for understanding warfare and crisis dynamics. For instance, Robert Jervis

16 This research's definition of the concept of the scopic regime is drawn from three sources, namely: Hendrik Huelss, “Transcending the Fog of War? US Military AI, Vision, and the Emergent Post-Scopic Regime,” *European Journal of International Security* 10, no. 2 (May 2024): 190–210, <https://doi.org/10.1017/eis.2024.21>; Kathrin Maurer, “Visual Power: The Scopic Regime of Military Drone Operations,” *Media, War & Conflict* 10, no. 2 (2016): 141–51, <https://doi.org/10.1177/1750635216636137>; and Kyle Grayson and Jocelyn Mawdsley, “Scopic Regimes and the Visual Turn in International Relations: Seeing World Politics through the Drone,” *European Journal of International Relations* 25, no. 2 (2018): 431–57, <https://doi.org/10.1177/1354066118781955>.

17 Rebecca Hersman and Bernadette Stadler, “When Is More Actually Less? Situational Awareness and Nuclear Risks,” *War on the Rocks*, August 2, 2019, <https://warontherocks.com/2019/08/when-is-more-actually-less-situational-awareness-and-nuclear-risks/>.

18 Huelss, “Transcending the Fog of War.”

argued that two of the crucial psychological factors interfering with decisionmaking quality are cognitive biases and stress. He highlighted that information processing tends to be skewed toward the belief that the adversary is prepared to attack. This perception can trigger aggressive actions framed as self-defense. Psychological factors may also lead decisionmakers to overestimate the advantages of a first strike, as fear amplifies the risk of miscalculation.¹⁹

There are many potential sources of pressure and anxiety that may be enhanced or induced by AI. First, pressure arises from the narrative and concerns surrounding machine speed; specifically, the integration of AI into military systems has created expectations that operations will occur at a pace faster than normal human judgment. As a result, decisionmakers, when required to act, feel anxious about keeping up with such speed, fearing a loss of control or the risk of being attacked.

Given the perception that adversaries are operating with AI and therefore at machine speed, along with the psychological bias of believing adversaries are inclined to attack, system alerts—such as detecting a potential threat or issuing an early warning—may lead to misguided decisions. These stress-induced decisions could include overreliance on the machine or the selective interpretation of information to align with preexisting beliefs (confirmation bias). The anxiety of having to act quickly is also likely to make decisionmakers or operators less inclined to double-check or fully utilize their other resources, which is already a complicated issue in itself concerning system effectiveness.

Beyond machine-speed concerns, fear is amplified when decisionmakers perceive their systems as vulnerable or as directly tied to escalation risks. Anxiety grows when weapon systems depend heavily on cyberspace and security, for example, since any adversarial penetration could compromise a large arsenal across multiple platforms. For those responsible, even minor signs of exploitation can heighten fears of losing control. Similarly, narratives about AI jeopardizing second-strike capability reinforce the pressure to act quickly, increasing the risk of premature or misguided decisions. In such tense scenarios, decisionmakers could potentially lose their own contextual insights and seek to avoid facing difficult decisions, which may again result in overreliance on, and biases toward, machine interpretations.²⁰

HUMAN-MACHINE INTERACTION, INTEGRATION, AND TEAMING

How, then, can nuclear deterrence remain effective in an era where AI applications increasingly challenge the human mind and its contribution to the regime? Many scholarly and policy debates about the role of human intelligence in the age of AI often involve the concept of human control, particularly in relation to the decision loop (in-the-loop, on-the-loop, and off-the-loop), along with how to ensure that human involvement in the process is “meaningful.”

While this discussion must continue, much of the discourse on this topic remains trapped in the (false) dichotomy between human and machine, human control and autonomy, or in reiterating the importance of sustained human involvement in AI systems which can also contribute to conceptual ambiguities regarding AI, which is fundamentally designed to function independently.

This research paper highlights the need to move beyond such debates and focus more on human

19 Jervis, *The Meaning of the Nuclear Revolution*, 148–73.

20 Jervis, *The Meaning of the Nuclear Revolution*, 148–73; and Horowitz and Lin-Greenberg, “Algorithms and Influence,” 1–12.

agency, particularly on humans' relationships with the systems, including recognizing that while AI is integrated into military operations, situational awareness systems, and other decision-support tools, the fact that humans are interacting with the machines can result not only in augmented decisionmaking but also in potential interference.²¹ The key concepts in this realm comprise human-machine interaction, integration, and teaming.²² Exploring these dynamics raises questions about the importance of efforts to understand the human element in nuclear deterrence strategy and decisionmaking, particularly regarding the impact of AI on the human mind within the deterrence equation, the contributions of human intelligence and insight to the system, and the pursuit of the question "Then what?," given that humans are already recognized as an important part of the regime and decisionmaking authority.

For the purposes of this paper—conceptualizing nuclear deterrence and the role of AI—the concept of human-machine teaming is particularly promising.²³ Human-machine teaming is founded on the hope that the military can achieve the best of both worlds, particularly on issues of situational awareness, where the expertise of both humans and machines are preserved without sacrificing either, and both work together as a team toward accomplishing the same goal without interfering with each other.²⁴

In an effort to navigate these challenges, policies need to be designed not only to strengthen human contributions but also to consider the holistic aspects of human agency. The SIGHT policy approach, developed with these principles in mind, is as follows:

- **S: System designed effectively, with human-centered principles in mind**

System effectiveness is critical in AI-enhanced situational awareness, as system failures can directly impact the perception, comprehension, and projection of the humans involved in the process. Investing in systems that not only accomplish their tasks but do so effectively, safely, and securely is essential.

Human-centered AI principles (HCAI), which include approaches such as transparency, trust, and explainable AI, should be considered a crucial part of the system design and engineering process.²⁵ It is also worth noting that research investment in understanding how to implement and apply HCAI may be necessary to advance these efforts.

21 Raluca Csernaton et al., "Myth, Power, and Agency: Rethinking Artificial Intelligence, Geopolitics and War," *Minds and Machines* 35, no. 37 (2025), <https://doi.org/10.1007/s11023-025-09741-0>.

22 While there are no set definitions for the concepts of interaction, integration, and teaming—as they are typically defined differently depending on the context—a central shared element is the recognition that humans are part of this equation, not only needing to be appreciated but also considered in all aspects of their interaction with the machine to ensure their contributions and strength.

23 Since there is no unified definition for human-machine teaming, one possible interpretation is that the concept of team could range from reducing (perhaps entirely eliminating) the role of humans to valuing both parties equally in terms of their contributions. It is therefore important that policymakers wanting to create such a framework first decide upon the values they wish to uphold and then design from them.

24 Realizing this vision requires addressing many obstacles and foundational understandings. For example, the element of "trust" between team members may need to be redefined in this context, and if so, the question becomes how. It is also worth noting that, as previously mentioned, the trust that humans have in machines and in themselves, in terms of perception, comprehension, and projection, supported by and in relation to AI, is a key factor in the quality of decisionmaking. Therefore, the concepts of human-machine teaming, interaction, and integration, represent a critical approach worth examining to address this strategic question.

25 Anna Hall, Patrick Murray, Ronald L. Boring, and Vivek Agarwal, "Human-Centered and Explainable Artificial Intelligence in Nuclear Operations," *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 68, no. 1 (2024): 1563–68, <https://doi.org/10.1177/10711813241276463>.

- **I: Interaction and integration between humans and machines, as well as between different military agencies and departments**

Efforts to understand human-machine integration, interaction, and teaming are key to addressing the impacts of AI on human judgment and decisionmaking, particularly as AI is applied to systems in nuclear deterrence. Once human agency is properly recognized, further studies on related topics, including cognitive biases and other psychological factors, should follow.

Research in this area may also benefit from examining the historical relationship between humans and technology across different eras and the implications of various technological advances. While questions of human control or meaningful involvement in the “loop” remain important, excessive focus on debating or reiterating human values and contributions, without further examination, may prove unproductive.

Collaboration between military agencies and departments is highly encouraged, not only because future integration of different departments’ information is likely to be valuable, but also because it will help officials become familiar with the potentially overwhelming amount and different kinds of data that may need to be acted upon.

- **G: Guidance documents provided to support human engagement with the system**

Properly circulated texts and official internal documents can help support navigation and foster a shared vision among departments and officials within the regime. Part of the confusion in discussions of AI and human judgment arises from the lack of a shared understanding regarding the direction of the technology, along with its applications and implications.

Guidance documents may include clearly listed implications and limitations of both AI and human agency, as well as recommended steps for officials facing difficult tasks or decisions and corresponding internal resources they can utilize. Specific statements on the value of human judgment, including the idea that there may be more than a millisecond to take action, could also be communicated. Developing such guidance will further support navigation and the development of other important elements, steps, and approaches for the desired specific frameworks, such as human-machine teaming and integration.

- **H: Human intelligence and insight valued, considered, and appreciated**

As human intelligence and insight continue to be greatly valued in decisionmaking, practices must be put in place that recognize and reinforce this contribution. Meetings and feedback sessions with officers working directly with the systems, along with exchanges among applicators, designers, and navigators, will be crucial to developing and sustaining norms and cultures that emphasize the importance of human intelligence. Continuous training and workshops for relevant officers in intelligence analysis, tailored to their specific tasks, should also be conducted routinely.

If research on human agency in the realm of nuclear deterrence is funded, all findings should be shared internally. The processes of intelligence analysis, as well as their outputs, should be designed to ensure that key human input and insight remain central. Relevant training and the continuous updating of contextual knowledge and situational awareness are essential in this regard. Although many activities are now supported by AI, all relevant training should still be routinely conducted, with additional emphasis on how to work with the systems effectively.

- **T: Training designed around not only scenarios but also stress management and system interaction**

As mentioned, all training relevant to officers' respective tasks remains essential for maintaining effective decisionmaking, intelligence analysis, and related contributions to the regime. Beyond routine training, additional programs should be developed to improve officers' and decisionmakers' understandings of the systems they work with, including applications, functions, and limitations, along with the officers' unique strengths that machines cannot replicate. Officers, in line with their roles, should be able to identify system failures when they occur and be equipped with the confidence to trust their own output and engagement with the system.

In addition to scenario-based training, officers should receive training in recognizing their own cognitive biases and managing stress. They should be prepared for the anxiety and tension that may arise in high-pressure environments in relation to the existence and application of AI. This may also include routine lectures on AI applications to the military, practical implications for nuclear deterrence, and adversaries' developments and perceptions of relevant systems. Officers should also be thoroughly familiar with the systems they work with, systems they may even come to view as part of their "team." Training should include managing potentially overwhelming volumes of data, understanding what internal resources are available, and knowing how to use those resources effectively when needed. Wargaming exercises are particularly valuable in this regard.

THE WAY FORWARD

This paper has explored the intricate dynamics of human cognition, AI integration, and situational awareness in the context of nuclear deterrence. It demonstrates that while AI offers powerful capabilities—including enhancing data processing, analysis, and predictive capacity—its integration also introduces unique psychological and operational risks. Illusion risks, algorithmic anxiety risks, and scopic regime risks highlight how humans' perceptions, comprehension, and projections can be shaped, distorted, or even overwhelmed by machine-supported decisionmaking. Recognizing that deterrence ultimately relies on the quality of human judgement and action, understanding these interactions is essential to preventing misperception, misinterpretation, or unwanted escalation.

Moving forward, sustaining effective deterrence requires a human-centered approach. Policy frameworks such as SIGHT, which emphasizes system design, integration, guidance, human intelligence, and training, offer a pathway to integrate AI responsibly while preserving human agency. Research, exercises, and interdepartmental collaboration should focus on identifying AI limitations, building human trust in machines, and maintaining the centrality of human insight in strategic decisions. Ultimately, the future of nuclear deterrence in an algorithmic age depends not on choosing between humans or machines, but on cultivating robust human-machine integration and interaction that safeguards decision quality, mitigates risk, and reinforces strategic stability in an increasingly complex world.



Imagining Artificial Intelligence in Nuclear Command, Control, and Communication

Between Fiction, Historical Analogy, and Technical Reality

By Philipp G. Rombach¹

INTRODUCTION: THE USE OF IMAGINARIES AND HISTORICAL ANALOGIES FOR AI IN NC3

Artificial intelligence (AI) has developed to a point where it is being integrated into complex systems across many different domains, including nuclear command, control, and communication (NC3) systems. Yet, it is often unclear what exactly is being meant by “AI” in academic and policy debates. At times, the term AI is used synonymously with tools like ChatGPT, conflated with automation, or confused with imaginary systems drawn from science fiction films and historical anecdotes that AI does not clearly map onto. Many scholars warn against integrating AI into NC3 systems by invoking so-called “imaginaries”: fictional narratives and historical analogies that serve as reference points for fears about the loss of human control, catastrophic accidents, and the existential risks of automated

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nuclear launch. Within this narrative, nuclear Armageddon occurs because AI is perceived to lack predictability, transparency, and explainability and to be vulnerable to tampering with training data, insider attacks, hacking, and spoofing.²

The importance of studying the impacts of AI and other emerging technologies on strategic stability is undeniable. However, it matters *how* these perceived and anticipated impacts of integrating AI into NC3 systems are studied. The frequent use of AI imaginaries to illustrate the risks and benefits of integrating AI into the nuclear enterprise demonstrates that the field is still grappling with how to understand the technology, which comes with significant policy implications. On the one hand, the use of AI narratives makes it easier to understand the technology's role in the nuclear domain. But in bringing the academic discourse to the level of imaginaries and historical anecdotes, the reality of what this emerging and disruptive technology may actually do could be lost.

Academic discourse is complicated both by the secrecy surrounding highly classified nuclear systems and by the inherent difficulty of understanding the various forms of AI and machine learning—not only as technologies in their own right but also in relation to the complex systems into which they are integrated. With such a wide range of potential applications, some have suggested viewing AI as an enabling technology akin to electricity or the internal combustion engine.³ The range of use cases for AI spans the entire nuclear domain, from NC3 to anti-submarine warfare and ballistic missile defense systems. This complicates analysis and discourse, especially where technological understanding falls short. As a shortcut to rational arguments and a substitute for highly complex technological analysis, scholars thus revert to imaginaries.

Imaginaries can play a useful role in bridging the gaps among technologists, policy experts, and the broader public. Yet the overreliance on imaginaries and historical anecdotes is skewing discourse in ways that prevent a deeper understanding of the risks and opportunities of using AI in nuclear systems. Academic discourse frequently references films such as *Dr. Strangelove* (1964) and *WarGames* (1983), alongside historical analogies focused on the Soviet Dead Hand system; the 1983 Petrov incident, in which a single Soviet officer, Stanislav Petrov, averted all-out nuclear war; and two friendly-fire incidents during Operation Iraqi Freedom in 2003, when automated Patriot missile batteries shot down allied aircraft.⁴ Each of these fictional and historical examples offers insights into automation in the nuclear enterprise, but taken together, they risk anchoring the discourse more in narrative than in technical reality.

This essay consequently takes a closer look at fictional narratives and historical analogies in the discourse on AI in NC3. First, this paper examines the role of historical analogies for decisionmakers and social scientists before exploring AI narratives more broadly. The main section presents a set of comparative case studies about the scholarly narratives surrounding the movie *WarGames*, the Soviet Dead Hand system, the 1983 Petrov incident, and the 2003 Patriot missile fratricides to better understand how the current discourse on AI in NC3 is framed. This paper concludes that the cumulative prevalence of fiction-based AI narratives and historical analogies risks shifting the debate into a less fruitful territory, where existential fears of automation-driven nuclear escalation are shaped more by imaginaries than by technological understanding.

2 Edward Geist and Andrew J. Lohn, *How Might Artificial Intelligence Affect the Risk of Nuclear War?* (Santa Monica, CA: RAND Corporation, April 2018), 19, https://www.rand.org/content/dam/rand/pubs/perspectives/PE200/PE296/RAND_PE296.pdf.

3 Michael C. Horowitz, "Artificial Intelligence, International Competition, and the Balance of Power," *Texas National Security Review* 1, no. 3 (2018): 39, <https://doi.org/10.15781/T2639KP49>.

4 "PONI Live Debate: AI Integration in NC3," CSIS, January 24, 2025, <https://www.csis.org/events/poni-live-debate-ai-integration-nc3>.

HISTORICAL ANALOGIES AND FOREIGN POLICY

National security decisionmakers and international relations scholars often make use of historical analogies because they are “functional, convenient, habitual and socially acceptable.”⁵ The use of history can aid in narration, illustration, and structuring of complex information and serve a “gap-filling” role by making use of historical analogies, metaphors, and extrapolations.⁶ By comparing present and future events to the past, scholars can use historical analogies as “a useful shortcut to rationality” and cognitive economization.⁷ References to history can serve various functions, including those of association, reality testing, causal inference, and predictive inference. Images of past events can feed into collective associative systems and become a background and prism through which the present and future can be compared, analyzed, and seen.⁸ Decisionmakers and scholars also use historical analogies as a “safety net and measuring rod” to compare the “credibility and validity” of information and expectations.⁹ Through predictive inference, historical events can be used to forecast future events through analogy and extrapolation.¹⁰ History thus directly influences policy, strategy, and scholarly analysis by aiding in problem recognition and constructing problem statements.

When decisionmaking and scholarly discourse are repeatedly anchored in the same historical events, those reference points become habitual and can influence the conclusions to be drawn from those events. According to prospect theory, this can lead to reference dependence such that preferences or analytical conclusions depend on the comparison to the initial reference point or historical anchoring.¹¹ While the past can anchor our knowledge in the present and future, adjustments need to be made, as many aspects of the present and future differ.¹² Without a nuanced approach to historical analogies, history can turn into a “grab bag from which each advocate pulls out a ‘lesson’ to prove [their] point.”¹³ While history can be the best teacher, the lessons of history seldomly lie on its surface.¹⁴

Yaacov Vertzberger, for example, argues that “the power of analogies that are used only for clarification, better understanding, and a more vivid argument, is such that they are sometimes taken, mistakenly, as proof for those arguments. In such cases, the plausibility which an analogy adds to an argument is confused with validity.”¹⁵ A similar argument cautioning against a simplistic use of historical analogies can be found in Robert Jervis, who argues that “a too narrow conception of the past and a failure to appreciate the impact of changed circumstances result in ‘the tyranny of the past upon the imagination.’”¹⁶ When making use of history for predicting the future, it is thus important to discuss the limitations of analogies. This is particularly the case when the impact of emerging technologies such as AI is compared to historical events that occurred with decades-old digital technologies operating on far inferior processing power and with far less computational

5 Yaacov Y. I. Vertzberger, “Foreign Policy Decisionmakers as Practical-Intuitive Historians: Applied History and its Shortcomings,” *International Studies Quarterly* 30, no. 2 (1986): 234, <https://doi.org/10.2307/2600677>.

6 *Ibid.*, 229–231.

7 Robert Jervis, *Perception and Misperception in International Politics* (Princeton, NJ: Princeton University Press, 1976), 220; and Vertzberger, “Foreign Policy Decisionmakers,” 243.

8 *Ibid.*, 225.

9 *Ibid.*, 226.

10 *Ibid.*, 227.

11 Daniel Kahneman and Amos Tversky, “Prospect Theory: An Analysis of Decision Under Risk,” *Econometrica* 47, no. 2 (1979): 263–292, <https://doi.org/10.2307/1914185>.

12 Vertzberger, “Foreign Policy Decisionmakers,” 240; and Jervis, *Perception and Misperception*, 220.

13 Jervis, *Perception and Misperception*, 217.

14 Kenneth Thompson, as cited in *ibid.*, 218.

15 Vertzberger, “Foreign Policy Decisionmakers,” 239.

16 Jervis, *Perception and Misperception*, 218.

sophistication. Similar pitfalls can be observed when making use of fictional stories to illustrate existential risks of future technologies.¹⁷

AI NARRATIVES IN SOCIAL SCIENCE DISCOURSE

The novelty and obscurity of AI, combined with the absence of more fitting comparisons, have inspired various sensationalist pop-culture analogies of AI-induced doomsday scenarios. Mischaracterizations further shape this scholarly debate, as AI is often conflated with automation or equated with large language models like ChatGPT. In this context, stories and narratives play a central role in shaping knowledge, culture, and values in society.¹⁸ They are central to the human condition and can act as “an important indicator of our vision of the future.”¹⁹ In the case of future technologies, fictional stories can serve as a “source of moral, political and technological imagination” and reframe society’s expectations.²⁰ Such “socio-technical imaginaries” shape public and elite perceptions and have the potential to impact real-world decisionmaking, thus influencing the future.²¹ In this regard, the governance of emerging technologies such as AI can be shaped by how discourse and narratives are framed.²² In public and scholarly discourse, fictional narratives can thus serve a similar function as historical analogies.

In cinematic portrayals, AI is typically depicted either as an existential threat or through “myopic solutionism,” such that intelligent machines are portrayed as simple solutions for complex problems.²³ Even if fictional, the prevalence of certain dominant narratives can distract and distort public perceptions by anchoring reference points in distinct AI narratives that may differ from real-world applications.²⁴ A common cinematic theme can be found in sentient and human-like machines that turn against their human creators by becoming overly powerful and superintelligent.²⁵ The perception of AI thus conveyed is one in which intelligent but emotion-free machines amplify the worst biases and characteristics of humanity. The dominant AI narrative in twentieth-century science fiction cinema is one in which humanity’s “longing for creation is connected with the anxiety that the creature will grow over our heads that we will lose control and finally be dominated by it.”²⁶ This “Frankenstein complex” of machines turning against humanity is a common feature in science fictional AI, as illustrated by the computer HAL9000 in *2001: A Space Odyssey* (1968) and *Deus Ex*

17 Jennifer Chubb, Darren Reed, and Peter Cowling, “Expert Views About Missing AI Narratives: Is There an AI Story Crisis?,” *AI & Society* 39 (2024): 1107, <https://doi.org/10.1007/s00146-022-01548-2>.

18 George Herbert Mead, as cited in Chubb, Reed, and Cowling, “Expert Views,” 1107.

19 Chubb, Reed, and Cowling, “Expert Views,” 1107.

20 Shannon Vallor, “Challenging and Redrawing Framings of Technology to Serve Human Flourishing and Justice,” *Edinburgh Innovations*, August 4, 2021, <https://edinburgh-innovations.ed.ac.uk/news/mobilising-the-intellectual-resources-of-the-arts-and-humanities>.

21 Sheila Jasanoff and Sang-Hyun Kim, *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power* (Chicago: University of Chicago Press, 2015); Chubb, Reed, and Cowling, “Expert Views,” 1107; and Jascha Bareis and Christian Katzenbach, “Talking AI into Being: The Narratives and Imaginaries of National AI Strategies and Their Performative Politics,” *Science, Technology, & Human Values* 47, no. 5 (2022): 855, <https://doi.org/10.1177/01622439211030007>.

22 Paolo Bory, Simone Natale, and Christian Katzenbach, “Strong and Weak AI Narratives: An Analytical Framework,” *AI & Society* 40 (2025): 2107–17, <https://doi.org/10.1007/s00146-024-02087-8>.

23 Chubb, Reed, and Cowling, “Expert Views,” 1107.

24 Ibid.; and Isabella Hermann, “Artificial Intelligence in Fiction: Between Narratives and Metaphors,” *AI & Society* 38 (2023): 319, <https://doi.org/10.1007/s00146-021-01299-6>.

25 Jascha Bareis and Thomas Christian Bächle, “The Realities of Autonomous Weapons: Hedging a Hybrid Space of Fact and Fiction,” in *The Realities of Autonomous Weapons*, ed. Thomas Christian Bächle and Jascha Bareis (Bristol, United Kingdom: Bristol University Press, 2024), 10–11.

26 Per Schelde, *Androids, Humanoids, and Other Folklore Monsters: Science and Soul in Science Fiction Films* (New York: New York University Press, 1993), cited in Hermann, “Artificial Intelligence in Fiction,” 322.

Machina in *The Matrix* (1999).²⁷ Dystopian narratives are particularly prevalent in movies exploring the integration of thinking machines into NC3 architectures. In movies such as *Colossus: The Forbin Project* (1970), *WarGames* (1983), and *Terminator 2: Judgment Day* (1991), automated machines amplify the existential threat of nuclear annihilation as human operators lose control over launch authority. In these movies, superintelligent computers are depicted as a human-like form of AI, thus instilling a negative bias against technology and modernity.²⁸

Other Cold War–era movies, such as *Dr. Strangelove* (1964), *Fail Safe* (1964), and *The Day After* (1983), follow a similar narrative in which machines or machine-like patterns of behavior outpace human control. These AI narratives rest not just in Mary Shelley’s 1818 novel *Frankenstein: The Modern Prometheus*, but also in ancient Greek mythology. One such myth can be found in the bronze automaton Talos, which was created to protect the inhabitants of Crete against pirates and invaders before the automaton turned against humans. On the other hand, Prometheus, the bringer of fire, has been used as an analogy for the creation of intelligent machines (*Frankenstein*) as well as an analogy for the creation of the atomic bomb.²⁹ The dystopia found in Western AI narratives rests to a certain extent on Greek mythology and, in the nuclear context, on the fear of nuclear annihilation, which prevailed throughout the Cold War. This stands in notable contrast to the AI imaginaries prevalent in Japanese cinematography, in which humans and machines cooperate and robots exhibit a soulful sentience.³⁰

In drawing analytical comparisons to science fictional AI, public discourse may take these narratives as factual representations of technologies. However, many AI narratives are less about the accurate depiction of technology but rather “a metaphor for other social issues.”³¹ Stories often revert back to an “omnipotent AI” to illustrate the “fear of impotence and helplessness of the individual in the face of superordinate structures.”³² Yet a similar feeling can be invoked in stories that focus less on technology and more on totalitarian political systems, as showcased in Franz Kafka’s *The Trial* (1925) and George Orwell’s *1984* (1949). This raises the question of the extent to which these socio-technical imaginaries influence analyses of incorporating AI into nuclear systems.

WARGAMES AND THE IMPACT OF NUCLEAR FICTION ON POLICYMAKING

Examining the impact of fictional movies on policymaking is inherently challenging and can, at times, border on esoteric. Fictional narratives or imaginaries typically exist in the background by feeding into collective associative systems.³³ Yet there are historical examples of fictional narratives directly impacting decisionmakers and influencing policymaking. As a product of Hollywood, President Ronald Reagan had a penchant for cinema throughout his years in the White House. In 1983, he was deeply influenced by not one but two movies on the existential threat of nuclear annihilation. In *The*

27 Peter W. Singer, “Isaac Asimov’s Laws of Robotics Are Wrong,” *Brookings, Commentary*, May 18, 2009, <https://www.brookings.edu/articles/isaac-asimovs-laws-of-robotics-are-wrong/>.

28 Steffan Puwal, “Should Artificial Intelligence Be Banned from Nuclear Weapons Systems?,” *NATO Review*, April 12, 2024, <https://www.nato.int/docu/review/articles/2024/04/12/should-artificial-intelligence-be-banned-from-nuclear-weapons-systems/index.html>.

29 Kai Bird and Martin J. Sherwin, *American Prometheus: The Triumph and Tragedy of J. Robert Oppenheimer* (New York: Vintage Books, 2006).

30 Chubb, Reed, and Cowling, “Expert Views About Missing AI Narratives,” 1114. A romantic and light-hearted Western science fiction movie can be found in *Wall-E* (2008). More hopeful AI narratives in Japanese cinematography can be found in *Astro Boy* (1952), *Evangelion* (1995), *Time of Eve* (2008), and *Ghost in the Shell* (2017).

31 Hermann, “Artificial Intelligence in Fiction,” 320.

32 *Ibid.*, 322.

33 Vertzberger, “Foreign Policy Decisionmakers,” 225.

Day After, the “bucolic and happy Midwestern town” of Lawrence, Kansas, is wiped out in a retaliatory nuclear attack.³⁴ As Reagan confided in his diary, the movie was “very effective & left me greatly depressed. . . . My own reaction was one of our having to do all we can to have a deterrent & to see there is never a nuclear war.”³⁵

Only four months earlier, another movie exploring existential nuclear dangers had become a major success at the box office. In *WarGames*, a teenage hacker played by Matthew Broderick accidentally dials up a computer at North American Aerospace Defense Command (NORAD). Unaware of the computer’s function, the teenager challenges the computer to a game of “Global Thermonuclear War.” The plot then closely resembles a real-world 1979 NORAD incident in which a training tape simulated a Soviet attack against the United States. Both in *WarGames* and at NORAD in 1979, the simulation was first mistaken for a real nuclear attack. Only when radar feeds did not corroborate the incoming missiles was it deemed a false alarm by the human operators. In the techno-thriller, the computer subsequently takes over launch control and threatens an all-out nuclear attack against the Soviet Union. Nuclear Armageddon can only be averted when the computer is trained through a game of tic-tac-toe that in nuclear war “the only way to win is not to play.”³⁶

Reagan was so deeply concerned about the possibility of a computer attack on the United States’ NC3 systems that he asked his chairman of the Joint Chiefs of Staff, John Vessey, whether the plot’s premise was plausible. A week later, Vessey replied: “Mr. President, the problem is much worse than you think.”³⁷ In those days, NORAD’s computers were incredibly vulnerable to anyone who dialed the right number, as Willis Ware, a former computer scientist for NORAD, had outlined in 1964.³⁸ Although NORAD computers did not have the authority to launch nuclear weapons, they played an important role in collecting and analyzing data on nuclear attacks.³⁹ Inspired by *WarGames*, the Reagan administration released National Security Decision Directive 145 in 1984, a classified directive governing the National Policy on Telecommunications and Automated Information Systems Security.⁴⁰

Reagan was not the only one inspired to act. In 1986, German hacker Markus Hess accessed classified computers at California’s Lawrence Berkeley National Laboratory in an attempt to steal nuclear secrets for the Soviet Union’s main spy agency, the KGB. Hess later claimed that he was inspired by a screening of *WarGames* on German television.⁴¹ Another hacker group, the 414s, is sometimes alleged to have been inspired by *WarGames* as well.⁴² Yet coincidentally, the teenage hackers from Milwaukee hacked into Los Alamos National Laboratory a month prior to the release of *WarGames*.⁴³

34 David E. Hoffman, *The Dead Hand: The Untold Story of the Cold War Arms Race and Its Dangerous Legacy* (New York: Anchor Books, 2009), 90.

35 Hoffman, *The Dead Hand*, 90–91.

36 *WarGames*, directed by John Badham (United Artists Sherwood Productions, 1983).

37 Erik Gartzke and Jon R. Lindsay, “The Cyber Commitment Problem and the Destabilization of Nuclear Deterrence,” in *Bytes, Bombs, and Spies*, ed. Herbert Lin and Amy Zegart (Washington, DC: Brookings Institution Press, 2018), 197.

38 Andrew Futter, *Hacking the Bomb: Cyber Threats and Nuclear Weapons* (Washington, DC: Georgetown University Press, 2018), 1; and Fred Kaplan, “‘WarGames’ and Cybersecurity’s Debt to a Hollywood Hack,” *New York Times*, February 19, 2016, <https://www.nytimes.com/2016/02/21/movies/wargames-and-cybersecuritys-debt-to-a-hollywood-hack.html>.

39 Futter, *Hacking the Bomb*, 1.

40 Gartzke and Lindsay, “The Cyber Commitment Problem,” 197.

41 Futter, *Hacking the Bomb*, 61.

42 Ibid.

43 Alex Orlando, “The Story of the 414s: The Milwaukee Teenagers Who Became Hacking Pioneers,” *Discover Magazine*, October 10, 2020, <https://www.discovermagazine.com/technology/the-story-of-the-414s-the-milwaukee-teenagers-who-became-hacking-pioneers>.

In scholarly literature on digital technologies in the nuclear domain, *WarGames* serves as a reference point in two different ways: either to illustrate the dangers of automated retaliatory launch systems or to showcase cybersecurity risks in NC3. While using *WarGames* as an illustration of the “most readily imagined and feared” use case of AI in NC3 is not uncommon in scholarly work, the comparison to automated launch systems is far from ideal.⁴⁴ After all, in the movie, the computer ultimately learns that nuclear war is unwinnable once it has received the proper training.

WarGames also serves as a fictional analogy for cybersecurity risks in NC3. While some scholars use the movie for anecdotal purposes, others rely on the *WarGames* scenario to fill gaps in knowledge on cyber vulnerabilities in NC3 architectures.⁴⁵ Scholars have used the *WarGames* scenario to warn that “states have doubled down on digital technologies within their NC3” in the four decades since the movie’s release.⁴⁶ However, the technology portrayed in the movie reflected the technology available at the time (dial-up modems and 8-bit personal computers) and cannot easily be compared with today’s technology, considering the rapid pace of technological advancement since 1983. The overall accuracy and timeliness of the movie are what allowed the Reagan administration to draw conclusions with real-world implications from it. Absent other historical analogies and fictional imaginaries, the scholarly community seems to return to *WarGames* for cyber and AI narratives, even though digital technologies have vastly improved since.

DR. STRANGELOVE AND THE SOVIET DEAD HAND SYSTEM

Perhaps the most referenced fictional story in the context of nuclear AI is Stanley Kubrick’s magnum opus, *Dr. Strangelove* (1964). In the political satire, an unauthorized nuclear attack against the Soviet Union triggers a doomsday device and results in total nuclear annihilation. Dr. Strangelove (himself a fictional amalgamation of nuclear strategist Herman Kahn, rocket engineer Wernher von Braun, and nuclear physicist Edward Teller) famously lectures the Soviet ambassador that “the whole point of a doomsday machine is lost if you keep it a secret!”⁴⁷ While some scholars use the satirical movie as a fictional analogy that highlights the dangers of unauthorized launch that could stem from cyber vulnerabilities, most reference *Dr. Strangelove* in the context of the real-world Soviet Dead Hand system—designed to guarantee a retaliatory nuclear launch in the event of a decapitating first strike.⁴⁸ Jill Hruby and M. Nina Miller argue that the “discussion of AI in NC3 recalls the long-ambiguous Soviet system called Perimetr [a version of the Dead Hand],” which Erik Gartzke and Jon Lindsay describe as “not unlike the doomsday device in *Dr. Strangelove*.”⁴⁹ Others reference the movie to illustrate that the Soviet Union could have increased its nuclear deterrence had it not kept the White House in the dark about the Dead Hand.⁵⁰ Valery Yarynich, the man who disclosed the existence

44 See Zachary Davis, “Artificial Intelligence on the Battlefield,” *PRISM* 8, no. 2 (2019): 125, <https://www.jstor.org/stable/26803234>; Sydney J. Freedberg Jr., “No AI for Nuclear Command & Control: JAIc’s Shanahan,” *Breaking Defense*, September 25, 2019, <https://breakingdefense.com/2019/09/no-ai-for-nuclear-command-control-jaic-shanahan/>; Hruby and Miller, *Assessing and Managing*, 11; Puwal, “Should Artificial Intelligence Be Banned”; and Geist and Lohn, *How Might Artificial Intelligence Affect the Risk of Nuclear War?*, 9–10.

45 Gartzke and Lindsay, “The Cyber Commitment Problem,” 197; and Futter, *Hacking the Bomb*, 55.

46 Jacquelyn Schneider, Benjamin Schechter, and Rachael Shaffer, “Hacking Nuclear Stability: Wargaming Technology, Uncertainty, and Escalation,” *International Organization* 77, no. 3 (2023): 1–2, <https://doi.org/10.1017/S0020818323000115>.

47 Nicholas Thompson, “Inside the Apocalyptic Soviet Doomsday Machine,” *Wired*, September 21, 2009, <https://www.wired.com/2009/09/mf-deadhand/>.

48 Futter, *Hacking the Bomb*, 85–87.

49 Hruby and Miller, *Assessing and Managing*, 11; and Gartzke and Lindsay, “The Cyber Commitment Problem,” 204.

50 Thompson, “Inside the Apocalyptic Soviet Doomsday Machine”; and John Borrie, “Cold War Lessons for Automation in Nuclear Weapon Systems,” in *The Impact of Artificial Intelligence on Strategic Stability and Nuclear Risk: Volume I, European-Atlantic Perspectives*, ed. Vincent Boulanin (Stockholm: Stockholm International Peace Research Institute, 2019), 47.

of a Soviet dead man's switch to the world, also compared the Perimetr/Dead Hand system to the doomsday machine in *Dr. Strangelove*.⁵¹

Even though Kubrick's classic serves as a great analogy for the Soviet Dead Hand system, it is not a fitting comparison when assessing the role of AI in NC3. As a reference point, *Dr. Strangelove* puts us immediately to the worst scenario imaginable—an imperturbable electronic machine presiding over humanity's fate. Instead, applications of AI in NC3 will likely be more nuanced, ranging from AI in early warning systems to predictive maintenance of critical components in the NC3 infrastructure. Strangelovian doomsday scenarios are also problematic anchoring points in public discourse surrounding the role of AI in nuclear deterrence, since only a few scholars argue in favor of such automated launch systems. With the exception of Adam Lowther and Curtis McGiffin, there appears to be consensus among scholars and practitioners that human control over nuclear launch will and should not be fully handed to machines.⁵² Lowther and McGiffin base their argument on increased attack-time compression, yet it is not immediately evident how the introduction of emerging technologies would lead to reduced reaction times. In fact, many have argued that automation might extend the time available under attack, as automated information gathering and sensor data fusion would improve situational awareness.⁵³ Lowther's advocacy for an American Dead Hand system was quickly rejected by Pentagon officials, and the 2022 Nuclear Posture Review formally reaffirmed that the United States aims to never employ nuclear weapons without a human in the loop.⁵⁴ This policy has since been echoed by the United Kingdom's Defense Artificial Intelligence Strategy.⁵⁵ General Anthony Cotton, commander of U.S. Strategic Command, reiterated the importance of human control in a 2024 address, and the outgoing Biden administration issued a national security memorandum limiting the role of AI in nuclear launch authorization.⁵⁶ This sentiment was echoed in an agreement between U.S. President Joe Biden and Chinese President Xi Jinping to keep humans in control of nuclear launches.⁵⁷

Although *Dr. Strangelove* serves as an illustrative analogy for the Soviet Dead Hand system, the Dead Hand itself is often not a fitting historical analogy, as it anchors the discourse on integrating AI into the nuclear domain in the issue of automated retaliatory nuclear launch. Even though scholarly sources mostly rely on David Hoffman's analysis of primary sources when talking about the Soviet Dead Hand and Perimetr systems, the accounts in academic literature vary widely—both

51 Valery E. Yarynich, *C3: Nuclear Command, Control Cooperation* (Washington, DC: Center for Defense Information, 2003), 10.

52 See Adam Lowther and Curtis McGiffin, "America Needs a 'Dead Hand,'" War on the Rocks, August 16, 2019, <https://warontherocks.com/2019/08/america-needs-a-dead-hand/>; and Adam Lowther and Curtis McGiffin, "America Needs a Dead Hand More than Ever," War on the Rocks, March 28, 2024, <https://warontherocks.com/2024/03/america-needs-a-dead-hand-more-than-ever/>.

53 Michael C. Horowitz, Paul Scharre, and Alexander Velez-Green, "A Stable Nuclear Future? The Impact of Autonomous Systems and Artificial Intelligence," arXiv (2019): 3–4, <https://arxiv.org/abs/1912.05291>.

54 Lt. Gen. Jack Shanahan responded to Lowther and McGiffin as follows: "I read that [and my] immediate answer is 'No. We do not.'" In Freedberg, "No AI for Nuclear Command & Control." On Nuclear Posture Review, see Michael Depp and Paul Scharre, "Artificial Intelligence and Nuclear Stability," War on the Rocks, January 16, 2024, <https://warontherocks.com/2024/01/artificial-intelligence-and-nuclear-stability/>.

55 Ibid.

56 Carley Welch, "AI Has Role to Play in Protecting American Nuclear C2 Systems: STRATCOM Head," Breaking Defense, October 28, 2024, <https://breakingdefense.com/2024/10/america-needs-ai-in-its-nuclear-c2-systems-to-stay-ahead-of-adversaries-stratcom-head/>; and Kevin Liptak, "Biden Makes Clear AI Can't Launch Nuclear Weapons as He Looks to Harness New Technology's Power," CNN, October 24, 2024, <https://www.cnn.com/2024/10/24/politics/joe-biden-artificial-intelligence-nuclear-weapons/index.html>.

57 Jarrett Renshaw and Trevor Hunnicutt, "Biden, Xi Agree that Humans, Not AI, Should Control Nuclear Arms," Reuters, November 17, 2024, <https://www.reuters.com/world/biden-xi-agreed-that-humans-not-ai-should-control-nuclear-weapons-white-house-2024-11-16/>.

on the degree of automation and on the distinctions between the Dead Hand and Perimetr. The terminological semantics can be tedious, but precision matters. Some scholars have argued that Dead Hand and Perimetr are simply the Western and Soviet terms, respectively, for one and the same system.⁵⁸ Others support Hoffman's account of the Dead Hand referring to a fully automated version that was rejected in favor of Perimetr, a system "that would automatically delegate launch authority to field commanders but would always require a human in the loop."⁵⁹ This distinction is important as it may be the source of a few misperceptions about the degree of automation and autonomy in the Soviet Union's version of a doomsday machine.

In the decade between 1974 and 1984, the Soviet Union engineered a command system, which—if activated by Soviet leadership—would ensure retaliation in the event of a decapitating nuclear first strike. During a time of high tension and common false alarms in Soviet and U.S. early warning systems, a nuclear posture of launch-on-warning was deemed to come with significant risks. Although "details remain sketchy" in the unclassified realm, the Soviet Union had drawn up the Dead Hand as a computer system that would guarantee "retaliation without human control."⁶⁰ Not surprisingly, the Soviet military felt uneasy about fully relinquishing control to a computer and instead pursued a semi-automatic version in Perimetr. From an underground command post deep inside the Ural Mountains, an officer was tasked with launching the Perimetr command rockets *if* the automatic system (a) was manually activated by Soviet leadership, (b) had lost contact to military and political leadership, and (c) determined through a network of radiological, seismic, and barometric pressure sensors that a nuclear attack had occurred.⁶¹ Comparable to the U.S. Air Force's Emergency Rocket Communications System, Perimetr command rockets would fly across the Soviet Union and transmit retaliatory launch orders down to the surviving Soviet missile silos.⁶² Yarynich, a former colonel in the Soviet Strategic Rocket Forces, questioned whether the human in the loop would follow through with a retaliatory launch after "half the globe [had] already been wiped out."⁶³ This brings back to mind the opening sequence in *WarGames*, in which a fifth of all launch officers fail to launch and are consequently replaced by a machine.

The majority of scholars writing about Perimetr and the Soviet Dead Hand system correctly identify the actual system in place as a semiautomatic system with launch authority pre-delegated to human officers.⁶⁴ Where historical analogies for AI in NC3 veer off is when the Russian Perimetr system is

58 Vincent Boulanin et al., *Artificial Intelligence, Strategic Stability and Nuclear Risk* (Stockholm International Peace Research Institute, 2020), 21; Saima Aman Sial, "Military Applications of Artificial Intelligence in Pakistan and the Impact on Strategic Stability in South Asia," in *The Impact of Artificial Intelligence on Strategic Stability and Nuclear Risk*, ed. Petr Topychkanov (Stockholm: Stockholm International Peace Research Institute, 2020), 46; Hruby and Miller, *Assessing and Managing*, 11; and James Johnson, "Deterrence in the Age of Artificial Intelligence & Autonomy: A Paradigm Shift in Nuclear Deterrence Theory and Practice?," *Defense & Security Analysis* 36, no. 4 (2020): 436, <https://doi.org/10.1080/14751798.2020.1857911>.

59 Geist and Lohn, *How Might Artificial Intelligence Affect the Risk of Nuclear War?*, 10.

60 Hoffman, *The Dead Hand*, 152.

61 "Condition 1: Verify the Perimeter system was activated. This activation meant that the military commanders or the Kremlin had given advance permission for the system to fire. Condition 2: Check whether contact had been lost with the military and political leaders. If the lines were out, if the hand was dead, this meant decapitation. Condition 3: Determine whether nuclear detonations were being felt by a network of special sensors that measured light, radioactivity, seismic shocks and atmospheric overpressure." In Hoffman, *The Dead Hand*, 152–153.

62 Philip Reiner and Alexa Wehsener, "The Real Value of Artificial Intelligence in Nuclear Command and Control," *War on the Rocks*, November 4, 2019, <https://warontherocks.com/2019/11/the-real-value-of-artificial-intelligence-in-nuclear-command-and-control/>.

63 Hoffman, *The Dead Hand*, 153.

64 See Jonathan Roberts et al., "Human vs Machine: The Role of Artificial Intelligence in Nuclear Weapons Systems," in *The 2020 UK PONI Papers*, ed. Luba Zatschina-McCreadie and To Plant (London: Royal United Services Institute, 2020), 105; Andrew Futter, "Disruptive Technologies and Nuclear Risks: What's New and What Matters," *Survival* 64, no. 1 (2022):

being described as “an automated command-and-control system,” “a fully automated command-and-control system,” an “ultrafast and automated” system that can “detect a nuclear attack and retaliate automatically,” or as a system which ensures that “a decision . . . is automatically made to launch a retaliatory strike” upon attack.⁶⁵ These factual errors are minor and understandable on an individual basis but distract the academic discourse on AI in NC3 in the cumulative. Thus, the goal is not to shame individual scholars but to highlight how imprecise reference points can have a life of their own and, over time, be taken as factual. This development is not helped by Russian media spreading unverified reports about an upgraded version of Perimetr, which now may use AI.⁶⁶

PETROV, THE MAN WHO SAVED THE WORLD?

In the discourse on nuclear AI, the fear of false alarms is a recurring feature. In this context, the Petrov incident is a common historical analogy used to warn about the risks of integrating AI into early warning systems. On September 26, 1983, Soviet Lieutenant Colonel Stanislav Petrov, a duty officer, received an alert from his early warning computer system about an incoming nuclear missile strike, which he correctly interpreted as what it truly was: a false alarm. In the aftermath, Petrov was hailed as the “man who saved the world.”⁶⁷

In the 1980s, Soviet and U.S. early warning systems were known to be prone to false alarms. Petrov’s early warning command bunker was thus “charged with validating any warnings of a surprise nuclear attack” coming from a newly installed space-based early warning system.⁶⁸ A constellation of nine Oko infrared satellites had been placed on combat duty in 1982 to increase decision time to 30 minutes, from 15 minutes, when relying only on radars. When Petrov’s computers showed five incoming intercontinental ballistic missiles (ICBMs), it was a result of an “unexpected effect” in which the sun lined up with the Cosmos 1382 Oko satellite so that infrared sunlight reflected in a non-scattering way off high-altitude clouds over Montana’s Malmstrom Air Force Base. Knowing that the system was new and flawed and realizing that the United States was unlikely to attack with only five ICBMs, Petrov reported the warning as a false alarm to the Soviet General Staff. Reportedly, the General Staff likewise asked for clarifications, suggesting that Petrov was not the only one that night questioning the accuracy of the alarms.⁶⁹

111, <https://doi.org/10.1080/00396338.2022.2032979>; Geist and Lohn, *How Might Artificial Intelligence Affect the Risk of Nuclear War?*, 10; Horowitz, Scharre, and Velez-Green, “A Stable Nuclear Future?,” 11–12; Zachary Kallenborn, “Giving an AI Control of Nuclear Weapons. What Could Possibly Go Wrong?,” *The Bulletin of the Atomic Scientists*, February 1, 2022, <https://thebulletin.org/2022/02/giving-an-ai-control-of-nuclear-weapons-what-could-possibly-go-wrong/>; Reiner and Wehsener, “Real Value of Artificial Intelligence”; Pavel Sharikov, “Artificial Intelligence, Cyberattack, and Nuclear Weapons—A Dangerous Combination,” *Bulletin of the Atomic Scientists* 74 (2018): 370, <https://doi.org/10.1080/00963402.2018.1533185>; Boulanin et al., *Artificial Intelligence, Strategic Stability and Nuclear Risk*, 22; and Beyza Unal and Patricia Lewis, *Cybersecurity of Nuclear Weapons Systems: Threats, Vulnerabilities and Consequences* (London: Chatham House, 2018), 11, <https://www.chathamhouse.org/sites/default/files/publications/research/2018-01-11-cybersecurity-nuclear-weapons-unal-lewis-final.pdf>.

65 Boulanin et al., *Artificial Intelligence, Strategic Stability and Nuclear Risk*, 21; Dmitry Stefanovich, “Artificial Intelligence Advances in Russian Strategic Weapons,” in *The Impact of Artificial Intelligence*, ed. Topychkanov, 26; Lowther and McGiffin, “America Needs a Dead Hand”; Gartzke and Lindsay, “The Cyber Commitment Problem,” 204; and Samuel Bendett, *The Role of AI in Russia’s Confrontation with the West* (Washington, DC: Center for a New American Security, May 2024), 8, <https://www.cnas.org/publications/reports/the-role-of-ai-in-russias-confrontation-with-the-west>.

66 Geist and Lohn, *How Might Artificial Intelligence Affect the Risk of Nuclear War?*, 10.

67 See *The Man Who Saved the World*, directed by Peter Anthony (Statement Film, 2013); and Henrik Syse and Martin Cook, “Robotic Virtue, Military Ethics Education, and the Need for Proper Storytellers,” *Conatus* 8, no. 2 (2023): 672, <https://doi.org/10.12681/cjp.35684>.

68 Geoffrey Forden, Pavel Podvig, and Theodore A. Postol, “False Alarm, Nuclear Danger,” *IEEE Spectrum* 37, no. 3 (2000): 33, <https://doi.org/10.1109/6.825657>.

69 Ibid.

While the Soviet Union maintained a launch-on-warning posture, it is unlikely that leadership would have launched a retaliatory strike before early warning radars had a chance to detect the missiles 10 to 15 minutes later. The principle that a nuclear launch needs to be detected by two separate and independent sensor systems (infrared satellites and early warning radars) in order to be confirmed is referred to as dual phenomenology. Adherence to the dual phenomenology principle was significantly strengthened the following year when the Soviet Union placed another early warning satellite in geostationary orbit (as opposed to Oko's highly elliptical Molniya orbits) to act as an additional backup and reference point. In the four decades since, the Soviet Union and later Russia gained “an enviable database of natural phenomena of use in designing future early-warning networks”—data that can also be used to train AI algorithms for early warning systems.⁷⁰

As David Hoffman argues, Petrov had many reasons to believe the attack to be a false alarm, even though the M-10 supercomputer reported the five missiles detected minutes apart with “high reliability.”⁷¹ Petrov knew that the space-based early warning system “was still troubled . . . and plagued by malfunctions.”⁷² The Oko satellites were unreliable, and their introduction was rushed. A similar picture emerged for Soviet radar systems. Just three weeks earlier, on September 1, 1983, a Soviet air defense radar station on Sakhalin mistook Korean Air Lines (KAL) flight 007 for an American RC-135 reconnaissance aircraft operating in the area. Flight KAL007 had navigated off-course due to a pilot error, resulting in an accidental shootdown that killed all 246 passengers and 23 crew members.⁷³ Out of 11 radar stations on Kamchatka and Sakhalin, 8 did not work properly.⁷⁴ The KAL007 tragedy, the rushed fielding of the Oko satellite constellation, and the computer system's past glitches all gave Petrov reason to pause. His decision was aided by the absence of visual sightings of incoming missiles from the optical telescope, which each Oko satellite used as a backup to its infrared sensors.⁷⁵

It would be plausible to argue that AI tasked with data fusion might have come to a similar conclusion—even when integrated into faulty Soviet-era technology. Integrating AI into highly advanced space-based and terrestrial sensor networks and early warning systems would likely further reduce false alarm rates—especially considering that a human would remain in the loop while operator bias could be reduced through AI.⁷⁶ Some scholars, however, have posited that “an early-warning system powered by machine learning would [have] wrongly identif[ied] that an attack is underway.”⁷⁷ The Petrov incident serves for many as a historical analogy that highlights the dangers of automating early warning systems. The incident shows the “importance of keeping humans and their common sense as a fail-safe mechanism” because “a decision to fully automate early warning would mean that there was no human operator—no Petrov—to prevent a false alarm from escalating.”⁷⁸ In this narrative, the “automated Oko nuclear missile early-warning system illustrates not only the fallibility of automated systems” but also shows that “only sheer luck has prevented

70 Ibid.

71 Hoffman, *The Dead Hand*, 10.

72 Ibid., 9.

73 Ibid., 72–79.

74 Ibid., 88.

75 Ibid., 7–11.

76 Jessica Cox and Heather Williams, “The Unavoidable Technology: How Artificial Intelligence Can Strengthen Nuclear Stability,” *Washington Quarterly* 44, no. 1 (2021): 74, <https://doi.org/10.1080/0163660X.2021.1893019>.

77 Boulanin et al., *Artificial Intelligence, Strategic Stability and Nuclear Risk*, 114.

78 Ibid., 128; and Michael C. Horowitz, “Artificial Intelligence and Nuclear Stability,” in *The Impact of Artificial Intelligence on Strategic Stability and Nuclear Risk: Volume I: European-Atlantic Perspectives*, ed. Vincent Boulanin (Stockholm: Stockholm International Peace Research Institute, 2019), 80.

such an occurrence thus far.”⁷⁹ This “illustrative example of the dangers of automation in nuclear decisionmaking” underlines that “this will probably make most nuclear-armed states unlikely to further automate the early warning or command-and-control processes.”⁸⁰

Crucially, the issue with the Petrov analogy lies in the usage of the word automated. The term sometimes suggests a degree of automation when, in reality, the Soviet early warning system made use of automatic processes only to a certain extent. Early warning satellites relying on infrared images and radar systems scanning the horizon with electromagnetic waves are inherently computerized for the simple reason that humans cannot perceive electromagnetic waves outside of the spectrum of visible light. AI can enhance some of these computerized (and automatic) systems by making sure that early warning radars can adapt intelligently to changing noise and clutter environments. Both clutter and noise change seasonally and throughout the day as a result of weather and other factors.⁸¹ AI integration can thus optimize the accuracy and resolution of radar systems and space-based infrared sensors.⁸² These benefits can be amplified when sensor data is fused from a variety of data feeds.⁸³ In this regard, the human operator is as much in the loop as they have been before. Whether AI is used or not, radar operators are forced to trust their machines to a certain extent since radars are highly complex and difficult to comprehend—even before AI is integrated. This illustrates how the anchoring of the discourse in the Petrov incident makes public discourse reference-point dependent. Grounding arguments against AI in the space-based sensors and early warning radars used in 42-year-old Soviet technology is flawed. It anchors the debate in the analogy of a scary false alarm as opposed to exploring the complex nature of the technological realities and possibilities of cognitive radars and sensor data fusion.

PATRIOT FRIENDLY-FIRE INCIDENTS

A similar picture emerges when it comes to historical references to two friendly-fire incidents in which mobile, ground-based Patriot air defense systems shot down two friendly aircraft during Operation Iraqi Freedom on March 24 and April 2, 2003. First, a British Tornado combat aircraft was mistaken for an Iraqi anti-radiation missile and engaged by an American Patriot system while the missile battery was in semiautonomous mode.⁸⁴ The target misidentification was compounded by the malfunctioning or inactiveness of the Tornado’s identification friend-or-foe (IFF) system, which would have broadcast the fighter as a friendly aircraft.⁸⁵ Yet it was “unwarranted and uncritical trust in automation” by the human operators that resulted in authorization of launch.⁸⁶ Two weeks later, an American F/A-18C Hornet was shot down by another Patriot missile due to a false ballistic missile track caused by electromagnetic interference.⁸⁷ As a reaction to the first fratricide, all Patriot batteries had turned their missile launchers into standby mode. This allowed the target seekers to remain in automatic engagement mode without

79 Malinda Meegoda, “Autonomous Weapons in the South Asian Context: Risks and Countermeasures,” in *The Impact of Artificial Intelligence*, ed. Topychkanov, 62–63.

80 Depp and Scharre, “Artificial Intelligence and Nuclear Stability”; and Horowitz, Scharre, and Velez-Green, “A Stable Nuclear Future?,” 15.

81 Merrill I. Skolnik, *Introduction to Radar Systems: Third Edition* (Columbus, OH: McGraw-Hill Education, 2000).

82 Ibid.

83 Ibid.

84 Paul Scharre, *Autonomous Weapons and Operational Risk* (Washington, DC: Center for a New American Security, 2016), 30, <https://www.cnas.org/publications/reports/autonomous-weapons-and-operational-risk>.

85 Kelsey Atherton, “Understanding the Errors Introduced by Military AI Applications,” Brookings, *Commentary*, May 6, 2022, <https://www.brookings.edu/articles/understanding-the-errors-introduced-by-military-ai-applications/>.

86 Scharre, *Autonomous Weapons*, 31.

87 Ibid.

the launchers actually engaging while on standby. Due to human failure, the battery was switched to ready mode, which, under the new procedure, “was tantamount to an order to fire.”⁸⁸ In both instances, the operators had not received adequate training to provide effective human oversight of automated processes and “trusted the system in a naïve manner.”⁸⁹

Engineers and computer scientists spend significant resources to improve human-machine teaming and prevent such incidents. Well-designed interfaces help human operators avoid overreliance on machines and ensure that automatic and autonomous features are used only within their intended limits. It is fair to conclude that “human operators did not fully understand the complex, highly automated systems they were in charge of” because they “effectively surrender[ed] judgement to machines.”⁹⁰ Subsequent U.S. Army investigations concluded that automation bias played a critical role in the accident.⁹¹ Although the incidents can serve as illustrative examples of the challenges of human-machine teaming and automation bias, they should not be used as proof against integrating AI in nuclear-adjacent supporting capabilities such as integrated air and missile defense. Some have argued that the Patriot incidents illustrate “one of the most serious challenges facing autonomous weapons—getting accurate training data.”⁹² Training data scarcity thus “sets autonomous systems up for inevitable failure.”⁹³ This conclusion may not be supported, however, when comparing the performance of the Patriot batteries during the 2003 Iraq War with the performance of a variety of air and missile defense systems in more recent years. The routine engagement of a high number of aerial and ballistic threats over Ukraine, Israel, and the Strait of Hormuz has provided the United States and its allies with valuable battlefield data collection.

The performance of a specific military technology two decades ago is a valuable data point, especially if it helps us imagine how human-machine teaming can fail. Yet it cannot serve as a sweeping argument against integrating AI into these systems. Nuance matters, and so does the anchoring of the comparison. There is a long list of incidents in which civilian aircraft have been shot down by air defense systems as a result of human error: Iran shot down Ukraine International Airlines flight 752 in 2020, pro-Russian separatists shot down Malaysia Airlines flight 17 in 2014, Ukraine shot down Siberia Airlines flight 1812 in 2001, the USS *Vincennes* shot down Iran Air flight 655 in 1988, and the Soviet Union shot down KAL flight 007 in 1983, to name the most prominent incidents. Thus, a better question may be: How could AI be used in missile defense systems to prevent fatal incidents as a result of human error?

CONCLUSION: BEYOND THE USE OF IMAGINARIES AND HISTORICAL ANALOGIES FOR AI IN NC3

Fictional narratives and historical analogies play a critical role in shaping how the integration of AI into the nuclear enterprise is understood, often emphasizing existential risks over more nuanced technological realities. As shown in the case studies of *WarGames*, the Soviet Dead Hand system, the 1983 Petrov incident, and the 2003 friendly-fire Patriot missile accidents, such reference points for

88 Ibid.

89 John K. Hawley, *Patriot Wars: Automation and the Patriot Air and Missile Defense System* (Washington, DC: Center for a New American Security, 2017), 7, <https://www.cnas.org/publications/reports/patriot-wars>.

90 Depp and Scharre, “Artificial Intelligence and Nuclear Stability”; and Horowitz, Scharre, and Velez-Green, “A Stable Nuclear Future?,” 8.

91 Atherton, “Understanding the Errors.”

92 Ibid.

93 Ibid.

AI in NC3 can help illustrate highly complex technical issues, but they can also misdirect attention by anchoring a debate in false or exaggerated fears. In the discourse on nuclear AI, narratives and imaginaries have been centered on launch computers, the fear of losing human control, and the creation of Strangelovian AI-enabled doomsday machines. This academic discourse in its cumulativeness risks sidelining more precise, context-dependent technological analyses on much narrower aspects of integrating AI into NC3. Moving beyond fictional imaginaries and imperfect historical analogies would allow scholars and practitioners to narrow and deepen the conversation by emphasizing the nuanced and complex realities of emerging and disruptive technologies. By grounding the discourse on AI in NC3 in imaginaries and anecdotes, there is a risk of displacing the more concrete and technical discussions so urgently needed for national security policy.

Nuclear Advances and Escalation Risks in Great Power Rivalry



Don't Believe the Hype(rsonic)

Implications of Russia's Novel Nuclear Weapons

By Alvina Ahmed¹

INTRODUCTION

In March 2018, Vladimir Putin promoted and unveiled Russia's five major novel "super weapons"—Kinzhalt, Avangard, Sarmat, Burevestnik, and Poseidon—and soon thereafter announced the Tsirkon hypersonic ship-launched missile as well.² Late 2024 saw the introduction of a new intermediate-range ballistic missile possessing hypersonic speed, Oreshnik, which Russia immediately used in its ongoing war in Ukraine.³ The Kremlin's rationale behind developing these new—and sometimes dual-capable—nuclear weapons systems was to possess capabilities that could counter U.S. precision strike munitions and evade U.S. and European missile defenses, in turn granting Russian forces both strategic advantages and operational superiority on the battlefield.⁴ However, open-source analyses of Russia's use of these systems to carry conventional payloads in Ukraine suggest that they do

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- 1 Alvina Ahmed is a readiness analyst in the U.S. Navy. The views expressed in this article are those of the author and do not necessarily reflect the official policy or position of the Department of the Navy or the U.S. government. The author would like to thank Dr. Anya Fink, Ms. Mary Chesnut, and the CSIS Project on Nuclear Issues team for their comments and feedback on this research.
 - 2 Samuel Bendett, Mathieu Boulègue, Richard Connolly, Margarita Konaev, Pavel Podvig, and Katarzyna Zysk, *Advanced Military Technology in Russia: Capabilities and Implications* (London: Chatham House, September 2021), 23, <https://www.chathamhouse.org/2021/09/advanced-military-technology-russia>.
 - 3 Alice Masquelier-Page, "Russia Has Used Its Hypersonic Oreshnik Missile for the First Time. What Are Its Capabilities?" Associated Press, December 9, 2024, <https://www.ap.org/news-highlights/spotlights/2024/russia-has-used-its-hypersonic-oresnik-missile-for-the-first-time-what-are-its-capabilities/>. Oreshnik is derived from the RS-26 Rubezh ICBM and is therefore sometimes not categorized as a novel capability. For the purposes of this research, Oreshnik will be referred to as a novel weapon system, as Moscow employed it in a similar manner in its ongoing war in Ukraine as it did Kinzhalt and Tsirkon.
 - 4 Hanna Notte, Sarah Bidgood, Nikolai Sokov, Michael Duitsman, and William Potter, "Russia's Novel Weapons Systems: Military Innovation in the Post-Soviet Period," *Nonproliferation Review* 28, no. 1–3 (February–June 2021): 61–93, <https://doi.org/10.1080/10736700.2021.1946271>.

not provide significant tactical utility. Therefore, this raises the following questions: What were the Kremlin's objectives in using the novel, dual-capable weapons systems in Ukraine? How well did it achieve these objectives? And what implications—both conventional and nuclear—do Russia's development and deployment of these capabilities have for NATO?

This paper first conducts a cross-case analysis of three instances when Russian forces deployed new nuclear weapon delivery systems—Kinzhal, Tsirkon, and Oreshnik—in its war in Ukraine. Second, drawing on these insights and other open-source expert analyses, the research discusses what conventional and nuclear implications Russia's novel delivery systems have for NATO. Finally, it provides recommendations for the alliance's defense planning.

BACKGROUND

Russian nuclear strategy has evolved over time. For the majority of the Cold War, even though the Soviet Union possessed nonstrategic nuclear weapons, Soviet leaders “did not explore the options for intermediate levels of nuclear warfare” in the same manner as their U.S. counterparts considered various levels of escalation.⁵ This shifted toward the end of the Cold War and into the post-Soviet era as Russia's conventional forces weakened and the United States made significant advancements in precision strike munitions.⁶ Some experts assert that late-Soviet military strategists began to address the question of escalation management and think of new ways to maintain the Soviet Union's deterrence against adversaries.⁷ For example, leaders may have pursued an “escalate to de-escalate strategy,” in which Moscow would use limited nuclear strikes to de-escalate a conflict before its adversaries threatened its survival.⁸ Other analysts claim that Russian strategy has increasingly called for employing conventional weapons accompanied by “the constant threat of nuclear use” to prevent aggression.⁹

Regardless of the reason for changes in its military thinking, Moscow began to develop its arsenal of novel nuclear-weapon delivery systems around the 2010s that it hoped would be able to evade U.S. missile defenses, in turn giving Russian forces both strategic and tactical advantages.¹⁰ Table 1 summarizes the key attributes, based on open-source assessments of each weapons system.

Moscow has used the threat of nuclear weapons to try to deter the West from intervening in Russian strategic goals even before its full-scale invasion of Ukraine in 2022. Specifically, in his 2018 speech to the Russian Federal Assembly, Putin showed an animated video depicting the Sarmat intercontinental ballistic missile (ICBM) traveling around an imaginary globe, with the warheads appearing to strike what looks like the landmass of Florida.¹¹ The video can be seen as a direct threat to the United States by alleging that Moscow's new weapons can strike the U.S. homeland, traveling so fast it evades both early warning radars and missile defenses.

5 Dima Adamsky, *The Russian Way of Deterrence: Strategic Culture, Coercion, and War* (Stanford, CA: Stanford University Press, 2024), 21.

6 Michael Kofman and Anya Loukianova Fink, “Escalation Management and Nuclear Employment in Russian Military Strategy,” *War on the Rocks*, August 31, 2023, <https://warontherocks.com/2022/09/escalation-management-and-nuclear-employment-in-russian-military-strategy-2/>.

7 Ibid.

8 Katarzyna Zysk, “Escalation and Nuclear Weapons in Russia's Military Strategy,” *RUSI Journal* 163, no. 2 (April/May 2018): 4–15, <https://doi.org/10.1080/03071847.2018.1469267>.

9 Dave Johnson, *Russia's Conventional Precision Strike Capabilities, Regional Crises, and Nuclear Thresholds* (Livermore, CA: Center for Global Security Research, 2018), 17, <https://cgsr.llnl.gov/sites/cgsr/files/2024-08/Precision-Strike-Capabilities-report-v3-7.pdf>.

10 Notte et al., “Russia's Novel Weapons Systems.”

11 “Vladimir Putin presents Russia's new Sarmat ballistic rocket,” YouTube video, posted by Guardian News, 01:02, March 1, 2018, https://www.youtube.com/watch?v=Sn_TDQbcUiA.

Table 1: Alleged Delivery Capabilities of Novel Russian Weapons

Name	Type	Maximum Speed	Range	Warhead
Sarmat	Liquid-fueled ICBM	Mach 20	16,000–18,000 km	Nuclear
Avangard	Maneuvering hypersonic glide vehicle with single payload	Mach 20–27	Over 10,000 km	Dual-capable
Burevestnik	Nuclear-powered, sustainer-propelled cruise missile	Below Mach 1	Theoretically unlimited	Nuclear
Poseidon	Nuclear-powered underwater drone	~110 km/h	Theoretically unlimited	Nuclear
Kinzhal	Aero-ballistic hypersonic missile	Mach 10	2,000–3,000 km	Dual-capable
Tsirkon	Sustainer-propelled maneuvering hypersonic antiship missile	Mach 5–9	500–750 km	Probably conventional
Oreshnik	Intermediate-range hypersonic ballistic missile	Mach 10–11	2,500–5,000 km	Dual-capable

Source: Hanna Notte, Sarah Bidgood, Nikolai Sokov, Michael Duitsman, and William Potter, “Russia’s Novel Weapons Systems: Military Innovation in the Post-Soviet Period,” *Nonproliferation Review* 28, no. 1–3 (February–June 2021): 61–93, <https://doi.org/10.1080/10736700.2021.1946271>; Jill Hruby, *Russia’s New Nuclear Weapon Delivery Systems: An Open-Source Technical Review* (Nuclear Threat Initiative, 2019), <https://www.nti.org/analysis/articles/russias-new-nuclear-weapon-delivery-systems-open-source-technical-review/>; and Robert Greenall and Chris Partridge, “What We Know About Russia’s Oreshnik Missile,” BBC, November 22, 2024, <https://www.bbc.com/news/articles/cvg07zw9vj1o>.

Since February 2022, Putin has consistently used nuclear saber-rattling to try to dissuade the West from providing aid to Ukrainian forces. On February 27, 2022—three days after the full-scale invasion of Ukraine—Putin ordered Russia’s nuclear forces to go on high alert, saying this decision was a response to Western support for Ukraine and sanctions imposed on Russia.¹² This order can thus be seen as a direct threat to the West even though there were no actual “muscle movements” among these forces, just increased manning of associated posts.¹³ This type of nuclear posturing continued. In 2023, Russia shifted some of its tactical nuclear weapons to Belarus, with Putin again stating this was a warning to the West.¹⁴ And in March 2024, Putin signaled that Moscow would be ready to use nuclear weapons if a threat to the “existence of the Russian state” arises.¹⁵

Later that year, Russia modified its nuclear doctrine. Among other changes, the amended text most notably declares that any aggression toward the Russian Federation or its allies “by any non-nuclear state with the involvement or support of a nuclear state is seen as a joint attack by them.”¹⁶ This statement is part of Moscow’s response to the West’s ongoing military support to Ukraine, indicating

12 Yuras Karmanau, Jim Heintz, Vladimir Isachenkov, and Dasha Litvinova, “Putin Puts Nuclear Forces on High Alert, Escalating Tensions,” Associated Press, February 27, 2022, <https://apnews.com/article/russia-ukraine-kyiv-business-europe-moscow-2e4e1cf784f22b6afbe5a2f936725550>.

13 Heather Williams, Kelsey Hartigan, Lachlan MacKenzie, and Reja Younis, “Russian Nuclear Calibration in the War in Ukraine,” CSIS, *CSIS Briefs*, February 23, 2024, <https://www.csis.org/analysis/russian-nuclear-calibration-war-ukraine>.

14 Andrew Osborn, “Putin Says Russia Put Nuclear Bombs in Belarus as Warning to West,” Reuters, June 17, 2023, <https://www.reuters.com/world/europe/putin-says-russia-positions-nuclear-bombs-belarus-warning-west-2023-06-16/>.

15 “Putin Warns Again That Russia is Ready to Use Nuclear Weapons if Its Sovereignty is Threatened,” Associated Press, March 13, 2024, <https://apnews.com/article/russia-ukraine-war-putin-nuclear-weapons-82ced2419d93ae733161b56fbd9b477d>.

16 “Full Text of Russia’s Updated Nuclear Doctrine,” Sputnik International, November 19, 2024, <https://sputnikglobe.com/20241119/full-text-of-russias-updated-nuclear-doctrine-1120932192.html>.

that it might view coordinated conventional attacks as an existential threat by a nuclear state, justifying Moscow's potential retaliation with nuclear force.

ANALYSIS

This research explores what the Kremlin's objectives have been in using its novel weapons systems in Ukraine and whether Moscow achieved them. Focusing on three cases in which new missiles—Kinzhal, Tsirkon, and Oreshnik—were used, this analysis looks at what targets the missiles struck in Ukraine and at any official statements from Russian leadership that allude to the motivation behind using these weapons. It also studies Western responses to Russia's use of the new capabilities to assess how well Moscow achieved its intended objectives. Ultimately, this research finds that the driving factors behind Moscow's decision to employ the new capabilities carrying conventional payloads likely are (1) to battle test the novel capabilities in Ukraine; (2) to retaliate against and demoralize Ukrainian forces; and (3) to make the West stop providing aid to Ukraine.

CASE 1: USE OF KINZHAL IN MARCH 2023

TARGETS AND DAMAGE

On March 9, 2023, Russia launched an unprecedented barrage of 81 missiles—which allegedly included six Kinzhals—across Ukraine. It is unclear what the missiles targeted, but the strikes caused damage to civilian and energy infrastructures in Kyiv, Kharkiv, Odesa, and Zaporizhzhia, as well as residential areas in Lviv Oblast and Dnipro, which resulted in at least six civilian fatalities.¹⁷ The barrage reportedly did not cause lasting damage to the energy infrastructure.¹⁸ Furthermore, Ukrainian air defenses claimed to have intercepted 34 missiles—though whether a Kinzhal was among them remains unclear, as Ukrainian authorities maintained secrecy on the details.¹⁹ Nevertheless, the scenario indicates that while the missile barrage was destructive overall, the use of advanced capabilities such as the six Kinzhal missiles did not provide Russia with an additional tactical advantage.

It is plausible that the use of Kinzhal missiles was a strategic message to the West. In late 2022, the United States agreed to provide Ukraine surface-to-air Patriot systems, which would help Ukrainian forces intercept Russian missiles and drones.²⁰ Such defenses are effective in shooting down legacy ballistic missiles, but hypersonic missiles such as the Kinzhal are supposedly more challenging to intercept.²¹ This suggests that Russian forces aimed to assess the Kinzhal's ability to evade existing air defenses in Ukraine. Since the missile barrage came a few months after Washington agreed to provide Ukraine with additional military aid, the Kremlin may have also intended to send a message to the West that further aid to Ukraine would lead to more escalatory behavior from Moscow.

17 Hanna Arhirova and Elena Becatoros, "Russian Missile Barrage Slams into Ukrainian Cities; 6 Dead," Associated Press, March 9, 2023, <https://apnews.com/article/ukraine-russia-war-kyiv-odesa-kharkiv-40714ec02d628a95458594da-6ba8a80e>.

18 "Why Would Russia Use Hypersonic Missile to Strike Ukraine?," Associated Press, March 10, 2023, <https://apnews.com/article/ukraine-russia-kinzhal-hypersonic-missiles-e0dc1e20e9dd53528c5381ca5fdee66a>.

19 Ibid.

20 Adam Pemble, "US-Made Patriot Guided Missile Systems Arrive in Ukraine," Associated Press, April 28, 2023, <https://apnews.com/article/russia-ukraine-war-patriot-missile-system-4c79f9110899ca1880a61f2d1f328179>.

21 "Hypersonic Missiles Arms Race: What You Need to Know," YouTube video, posted by Carnegie Endowment, May 28, 2020, 5:31, <https://www.youtube.com/watch?v=s5Cj9oGkN8k&t=1s>.

RUSSIAN STATEMENTS

Russia's Ministry of Defense reportedly stated that the barrage was a "strike of retribution" for Ukrainian sabotage of villages in the Russian Bryansk region in February 2023.²² This suggests Russian forces used the novel weapons system to retaliate against Ukraine and force it to yield.

THE WEST'S RESPONSE

Though the United States did not specifically address Russia's use of Kinzhals, then-U.S. Secretary of Defense Lloyd Austin emphasized the importance of providing support to Ukraine at the Tenth Ukraine Defense Contact Group meeting on March 15, 2023, six days after Russia's use of Kinzhals.²³ Notably, at this meeting, Austin reiterated that the United States would provide Ukraine with an additional \$400 million in security assistance which would help support "precision fires, artillery, and armored vehicle operations."²⁴ In addition, about a week after the attack, EU leaders approved a plan to send 1 million 155 mm artillery shells to Ukraine by the end of March 2024.²⁵

It is noteworthy that at the time of the March 2023 missile barrage, Ukraine did not possess the capability to shoot down hypersonic missiles. However, that May, Ukrainian forces reportedly intercepted multiple Kinzhal missiles with the U.S.-supplied Patriot defense systems that had since arrived.²⁶ These interceptions challenged Moscow's long-standing claims that the Kinzhal was effectively invincible and beyond the reach of any existing Western defenses.

CASE 2: USE OF TSIRKON IN MARCH 2024

TARGETS AND DAMAGE

On March 25, 2024, Russia launched two Tsirkon missiles at Kyiv, reportedly targeting the Security Service of Ukraine (SBU) headquarters.²⁷ According to the Ukrainian Ministry of Defense, both missiles were reportedly intercepted by air defense systems, but debris from the strike fell and some civilians were injured as a result.²⁸

RUSSIAN STATEMENTS

Russian officials claimed that both missiles hit their intended targets, reportedly military and government sites such as the SBU, which is responsible for Ukraine's military, intelligence, and counter-intelligence functions, as well as the protection of Ukraine's president and parliament.²⁹ However, Ukrainian assessments claim that both missiles were successfully intercepted before

22 Ibid.

23 "Opening Remarks by Secretary of Defense Lloyd J. Austin III at the Tenth Ukraine Defense Contact Group (As Delivered)," U.S. Department of Defense, March 15, 2023, <https://www.war.gov/News/Speeches/Speech/Article/3329644/opening-remarks-by-secretary-of-defense-lloyd-j-austin-iii-at-the-tenth-ukraine/>.

24 Ibid.

25 "EU to Deliver One Million Artillery Shells to Ukraine," *Brussels Times*, March 20, 2023, <https://www.brusselstimes.com/eu-affairs/417764/eu-to-deliver-one-million-artillery-shells-to-ukraine>.

26 Scott Neuman, "Ukraine Says Its Newly Fielded U.S. Patriot System Downed a Russian Hypersonic Missile," NPR, May 6, 2023, <https://www.npr.org/2023/05/06/1174505616/ukraine-patriot-defense-russian-hypersonic-missile-kinzhal>.

27 Anna Murashko, "Media: Russia's Missile Attack on Kyiv: SBU Was the Main Target," Ukrainian National News, March 25, 2024, <https://unn.ua/en/news/media-russias-missile-attack-on-kyiv-sbu-was-the-main-target>.

28 Defense Express, "The Armed Forces of Ukraine Shot Down Two 'Analog' 'Zircons' That the Russian Federation Used to Attack Kyiv (in Ukrainian)," Defense Express, March 25, 2024, https://defence-ua.com/news/zsu_zbili_odrazu_dva_analogovni-jetni_tsirkoni_jakim_rf_bila_po_kijevu_ulamki_zaraz_skazhut_znachno_bilshe-14843.html.

29 "Russian Forces Carried out 58 Airstrikes, Including via Tsirkon Missiles, in 7 Days," TASS, March 30, 2024, <https://tass.com/defense/1768199>; and "Sluzhba Bespeky Ukrayiny (SBU)," Global Security, accessed October 9, 2025, <https://www.globalsecurity.org/intell/world/ukraine/sbu.htm>.

impact.³⁰ Moscow's possible exaggeration of Tsirkon's effectiveness implies that Russian officials may have attempted to conduct psychological warfare utilizing a show of force. But if Ukraine's claims are correct, these missile strikes instead exposed the limitations of the Tsirkon's capabilities.

THE WEST'S RESPONSE

The United States and NATO do not appear to have responded specifically to the strike on March 25, 2024. A few months later, at the NATO summit in Washington, member states reaffirmed their commitment to a minimum baseline funding of €40 billion (\$43 billion) for Ukraine's security assistance within the next year.³¹ This demonstrates that if Russia had meant to convince the West to stop giving aid to Ukraine, it failed to do so.

CASE 3: USE OF ORESHNIK IN NOVEMBER 2024

TARGETS AND DAMAGE

On the morning of November 21, 2024, Moscow employed Oreshnik—its newest intermediate-range ballistic missile (IRBM) with hypersonic speed. The strike targeted Dnipro, an eastern Ukrainian city home to Pivdenmash, a major rocket-manufacturing site.³² The extent of the damage remains unclear, though some sources claim the strike caused limited destruction.³³

RUSSIAN STATEMENTS

The use of Oreshnik came only two days after Washington authorized Ukraine to use the U.S.-made Army Tactical Missile System (ATACMS) to strike targets inside Russia itself, a move it had previously prohibited, and just one day after Ukraine fired UK-made Storm Shadow missiles into Russia.³⁴ Following the strike on Dnipro, Putin delivered a televised address asserting that the attack was a response to “the escalation of the conflict in Ukraine, instigated by the West, [which] continues with the United States and its NATO allies previously announcing that they authorise the use of their long-range high-precision weapons for strikes inside the Russian Federation.”³⁵ A week later, Russian media outlet RT also released a graphic depicting how long it would take Oreshnik, if launched from southwestern Russia, to strike London, Paris, Berlin, and Warsaw (see Figure 1). The graphic indicates Russian officials' belief that communicating Oreshnik's ability to hold major European capitals at risk would pressure NATO to back down from its support of Ukraine.

THE WEST'S RESPONSE

Western officials condemned the attack, with German Chancellor Olaf Scholz calling it a “terrible escalation.”³⁶ While NATO held an emergency meeting with Kyiv in response, it did not waver in its

30 “The Armed Forces of Ukraine,” Defense Express.

31 NATO, “Washington Summit Declaration,” press release, July 10, 2024, https://www.nato.int/cps/en/natohq/official_texts_227678.htm.

32 Phil Stewart and Idrees Ali, “US Believes Russia's Attack in Ukraine Showcased New Missile,” Reuters, November 21, 2024, <https://www.reuters.com/world/us-believes-russias-attack-ukraine-showcased-new-missile-2024-11-21/>.

33 Tom Balmforth and Gerry Doyle, “New Russian Missile Fired at Ukraine Carried Warheads Without Explosives, Sources Say,” Reuters, November 26, 2024, <https://www.reuters.com/world/europe/new-russian-missile-fired-ukraine-carried-warheads-without-explosives-sources-2024-11-26/>.

34 Dmitry Antonov and Andrew Osborn, “Russia Says Hypersonic Missile Strike on Ukraine Was a Warning to ‘Reckless’ West,” Reuters, November 22, 2024, <https://www.reuters.com/world/europe/kremlin-says-hypersonic-missile-strike-ukraine-was-warning-west-2024-11-22/>.

35 RT, “Putin Outlines Moscow's Response to Ukraine Escalation (Full Speech),” RT International, November 21, 2024, <https://www.rt.com/russia/608008-putin-ukraine-full-speech/>.

36 Reuters and Agence France-Presse, “New ‘Oreshnik’ Missile Fired by Russia Travelled Faster Than Mach 11, Ukraine Says,” ABC News (Australia), November 22, 2024, <https://www.abc.net.au/news/2024-11-23/ukraine-war-new-russian-missile->

support for Ukraine, demonstrating that Russia failed in this regard.³⁷ Following the strike, some Western analysts deduced that Oreshnik—while faster and harder to intercept than Soviet legacy missiles—tends to lack accuracy in hitting targets. Weapons such as Iran’s Shahed drones or Russia’s Kh-101 cruise missiles, which Russia has been using since the beginning of the full-scale invasion of Ukraine, would have been more accurate and cost-effective.³⁸ This implies that Moscow, rather than attempting to gain battlefield advantage, had a more strategic rationale in employing Oreshnik, likely as an intimidation tactic against the West.

Figure 1: RT Graphic Portraying Flight Times for Oreshnik to Strike Major European Capitals



Source: RT (@RT_com), “Oreshnik missile: How fast can it reach major European cities?,” X, November 28, 2024, 1:40 p.m., https://x.com/RT_com/status/1862204813557014786.

FINDINGS AND IMPLICATIONS

Scrutinizing the three cases, it is evident Russia used a relatively small number of the expensive, novel missiles in each of the barrages rather than expending them excessively. Together with previous official statements claiming that these new capabilities are invulnerable to Western air defenses, this observation suggests the Kremlin saw Ukraine as a testing ground to evaluate whether the capabilities could penetrate Western-supplied air and missile defenses. To Moscow’s disadvantage, however, the cases indicate that some of the novel capabilities are vulnerable to Western-supplied air and missile defenses, which reportedly intercepted the Tsirkon and Kinzhal missiles.³⁹

oreshnik-travelled-mach-11/104638254.

³⁷ Ibid.

³⁸ Sidharth Kaushal and Matthew Savill, “The Oreshnik Ballistic Missile: From Russia with Love?,” Royal United Services Institute, December 10, 2024, <https://www.rusi.org/explore-our-research/publications/commentary/oreshnik-ballistic-missile-russia-love>.

³⁹ Kateryna Denisova, “Air Force: Ukraine Can Down Zircon Hypersonic Missile with Patriot, SAMP/T,” Yahoo! News, March 27, 2024, <https://www.yahoo.com/news/air-force-ukraine-down-zircon-213257512.html>.

Some Russian officials asserted that the attacks were “strikes of retribution,” implying that one of Moscow’s objectives in employing the novel capabilities was to demoralize Ukrainian forces by targeting civilian infrastructure and critical supplies.⁴⁰ Russia was unable to capitalize on this, however, as the Kinzhal and Tsirkon strikes purportedly did not cause lasting damage and the extent of the damage caused by Oreshnik was unclear.

Finally, all three of the cases—and particularly the November 2024 barrage involving Oreshnik—demonstrate that Moscow’s key objective was to compel the West to withdraw its support for Ukraine. As with Russia’s other objectives, this failed: NATO allies continued to reaffirm their support, expediting shipments of air and missile defenses, providing long-range missiles, and committing to baseline funding.

While the size and diversity of Russia’s nuclear arsenal remain a significant threat to NATO and its partners, lessons from Ukraine demonstrate that the novel nuclear weapons systems do not provide a decisive advantage for Russian forces, either strategically or tactically. Some of these capabilities—at least when armed with conventional payloads—evidently are not significantly more effective than legacy weapons. The novel weapons systems may provide a marginal edge in terms of speed, maneuverability, and time-to-target efficiency since most of them have hypersonic capabilities. They are, in theory, more difficult for early warning radars to track and missile defense interceptors to engage than legacy ballistic missiles. However, as seen on the battlefield in Ukraine, air defenses such as Patriot can reportedly still counter and shoot some of them down.

CONVENTIONAL IMPLICATIONS

To fully understand the conventional implications of these capabilities for NATO, it is necessary to analyze what risks each system poses and identify some specific NATO targets each capability can threaten:

- 1. Kinzhal:** As seen on the battlefield in Ukraine, the air-launched Kinzhal gives Russia the option to execute quick regional attacks. In a NATO-Russia conflict, Moscow could potentially employ Kinzhal to strike targets in the Black Sea, Baltic States, Poland, and some bases in the Northern Flank. Nonetheless, as observed in Ukraine, Kinzhal missiles may be vulnerable to Western air defenses, making it likely that NATO could engage and neutralize the missiles.
- 2. Tsirkon:** As a ship-launched missile with a range of around 1,000 km, Tsirkon could be employed against NATO frontline states. Since it is an antiship missile, Russian forces might use it to target NATO’s naval assets in the Baltic or Black Seas. As with the Kinzhal, however, lessons learned from Ukraine demonstrate that the Tsirkon may also be vulnerable to Western air and missile defenses.
- 3. Oreshnik:** The Oreshnik has intermediate range, implying that it could strike European capitals, military bases, or other critical assets across the continent in the event of a NATO-Russia conflict. That said, analysts have pointed out that Oreshnik demonstrates limited accuracy in hitting intended targets.⁴¹ This may mean that in a conflict scenario, rather than using it as a tool to gain tactical advantage, Moscow may employ Oreshnik to pressure NATO to stop supplying the frontlines—or even to surrender.

40 “Why Would Russia Use Hypersonic Missile to Strike Ukraine?,” Associated Press.

41 Kaushal and Savill, “The Oreshnik Ballistic Missile.”

NUCLEAR AND STRATEGIC IMPLICATIONS

Lessons learned from the use of Kinzhal, Tsirkon, and Oreshnik in Ukraine cannot shed insight regarding Avangard, Poseidon, Burevestnik, and Sarmat, as they are fundamentally different capabilities. Nevertheless, some experts argue that these weapons do not necessarily “alter the strategic status quo between Russia and the United States” since they do not seem to provide Russia with substantial strategic advantages beyond its arsenal of legacy systems, which already possess a credible second-strike capability.⁴² Still, as the novel weapons systems supposedly have hypersonic capabilities, they may have a marginal edge in terms of speed and maneuverability over their legacy counterparts. Therefore, in a scenario where a NATO-Russia conflict escalates to nuclear hostility, there would be several advantages for Russia:

- 1. Lessened reaction time for U.S. leadership:** This applies for Avangard (hypersonic glide vehicle) and Sarmat (heavy ICBM), as they can travel at hypersonic speeds.⁴³ By the time U.S. tracking systems detect the missiles, Washington would have limited time to respond. The novel capabilities could allegedly strike the United States within about 15 minutes of being launched from Russia—half the average time it takes for land-based legacy ICBMs to cross the globe.⁴⁴
- 2. Loitering capabilities:** The Burevestnik cruise missile and Poseidon (underwater autonomous uncrewed vehicle) may possess loitering capabilities not present in Soviet-era legacy weapons. In a NATO-Russia conflict, these weapons systems could potentially hang around the U.S. homeland or in the water near U.S. ports, a show of force demonstrating that Moscow can escalate if it chooses.⁴⁵
- 3. Leverage to execute psychological warfare:** Based on the insights gained from Russia’s use of Kinzhal, Tsirkon, and Oreshnik in Ukraine and ongoing nuclear saber-rattling, it is likely that Moscow would engage in psychological warfare in a NATO-Russia conflict by brandishing the novel capabilities. It could portray these nuclear weapons systems as invincible and capable of causing devastating damage to NATO allies. As Moscow has attempted to do by striking territories in Ukraine, this strategy would aim to pressure NATO into backing down.

DUAL-CAPABLE DANGER

Analysts have identified the risk of entanglement—confusing conventional weapons with nuclear ones in relation to dual-capable systems such as the Avangard, Kinzhal, and Oreshnik—as destabilizing.⁴⁶ Unless covert intelligence or military-to-military talks indicate otherwise, if the United States detects an incoming novel weapons system during a NATO-Russia conflict, it may not know if it is carrying a conventional or nuclear payload. Washington might respond by assuming it is nuclear, which could lead to inadvertent nuclear escalation.

42 Spenser A. Warren, “Russian Novel Nuclear Weapons and War-Fighting Capabilities,” *US Army War College Quarterly: Parameters* 55, no. 2 (Summer 2025): 39–52, <https://doi.org/10.55540/0031-1723.3330>.

43 Hruby, *Russia’s New Nuclear*.

44 Peter Pella, *The Continuing Quest for Missile Defense: When Lofty Goals Confront Reality* (San Rafael, CA: Morgan and Claypool, 2018), 1–9, <https://iopscience.iop.org/book/mono/978-1-6817-4942-6/chapter/bk978-1-6817-4942-6ch1>.

45 Matthew Kroenig, Mark J. Massa, and Christian Trotti, “Russia’s Exotic Nuclear Weapons and Implications for the United States and NATO,” Atlantic Council, March 6, 2020, <https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/russias-exotic-nuclear-weapons-and-implications-for-the-united-states-and-nato/>.

46 Christine Parthemore and Catherine Dill, “Paint the B-52s Brightly: Reducing Confusion Between Conventional and Nuclear Weapons Is Essential,” *War on the Rocks*, September 17, 2024, <https://warontherocks.com/2024/09/paint-the-b-52s-brightly-reducing-confusion-between-conventional-and-nuclear-weapons-is-essential/>.

RECOMMENDATIONS FOR NATO DEFENSE PLANNING

NATO's strategic goals should withstand Russia's coercive attempts, and the alliance should resist conceding to Moscow's demands if Russia employs more of these weapons in Ukraine or against a member state. Assuming its current conventional balance and nuclear deterrence efforts remain unchanged (i.e., U.S. extended deterrence, modernization of U.S. and UK nuclear forces, and NATO nuclear sharing), NATO should take the following actions:

- 1. Continue providing aid to Ukraine.** Russia's strikes against Ukraine using the Kinzhal, Tsirkon, and Oreshnik caused destruction to civilian infrastructure. Nevertheless, open-source assessments suggest that the strikes gave Russia very limited, if any, tactical advantage. Russia does not possess a large number of the novel weapons due to their cost of manufacturing. Therefore, it would be strategic for NATO to allow Moscow to waste resources on capabilities that do not grant it significant warfighting advantage. Rather, NATO should continue supplying Ukraine with weapons that can penetrate deep inside Russia; this move would signal to the Kremlin that any show of force using the novel weapons would be fruitless. Moreover, the United States should supply Ukraine with more Patriot defenses, which allegedly intercepted several of the Kinzhal missiles in 2023 and 2024.⁴⁷ Doing so could alter Russia's risk calculus and help it realize that the probability of the novel weapons systems hitting their targets is low, leading to deterrence by denial.
- 2. Invest in developing and posturing precision-guided munitions.** One of Moscow's original motivations behind developing the novel capabilities was to counter U.S. precision-guided munitions.⁴⁸ Indeed, in the post-Cold War era, Russia observed several NATO member states' forces prevail in Yugoslavia and Iraq, conflicts in which these weapons played a significant role in NATO's success.⁴⁹ U.S. precision-guided missiles are significantly more accurate than Russia's novel weapons systems, as they "typically use the global positioning system (GPS), laser guidance, or inertial navigation systems to improve a weapon's accuracy to reportedly less than 3 meters."⁵⁰ Precision-guided munitions are thus theoretically able to hold at risk specific Russian targets such as anti-access/area denial (A2/AD) nodes, airfields hosting advanced weapon systems, surface-to-air missile (SAM) systems, and certain command and control posts. Threatening to target these assets would signal to Russia that the alliance could deliver catastrophic damage to assets Moscow considers critical, even without the use of nuclear weapons. Posturing and dispersing precision strike missiles effectively among NATO frontline states may bring about deterrence by punishment: Russia may not want to escalate a conflict if it believes that even a conventional response from NATO would be cataclysmic. One potential posture plan is outlined in Table 2.
- 3. Enhance the alliance's combined force readiness.** "Force readiness" refers to the military's ability to effectively mobilize in response to a crisis at any given time.⁵¹ In a conflict with

47 "Patriot Air Defence System Intercepted 25 Kinzhal Missiles in Ukraine," Defence Industry Europe, January 8, 2024, <https://defence-industry.eu/patriot-air-defence-system-intercepted-25-kinzhal-missiles-in-ukraine/>.

48 Notte et al., "Russia's Novel Weapons Systems."

49 Andrey Sushentsov, "The Russian Response to the RMA: Military Strategy Towards Modern Security Threats," in *Reassessing the Revolution in Military Affairs: Transformation, Evolution and Lessons Learnt*, eds. Jeffrey Collins and Andrew Futter (London: Palgrave Macmillan, 2015), 115.

50 John R. Hoehn, "Defense Primer: U.S. Precision-Guided Munitions," Congressional Research Service, IF11353.6, updated August 25, 2020, https://www.congress.gov/crs_external_products/IF/PDF/IF11353/IF11353.6.pdf.

51 Luke A. Nicastro, "Military Readiness: DOD Assessment and Reporting Requirements," Congressional Research Service, IF12240, October 26, 2022, <https://www.congress.gov/crs-product/IF12240>.

Russia, one of the challenges NATO would face is how to bring the bulk of munitions from Western Europe and the United States to the front lines. Russia might leverage this time window and show force using novel weapons systems to pressure Western forces to keep out of the conflict. One action NATO can take is to enhance the readiness of its forces in peacetime, thereby shortening this time window. Improving combined force readiness would also have warfighting advantages, as more NATO troops would be able to reach the front lines quickly and could deter Moscow from escalating the conflict.

Table 2: Recommended Posture Plan to Strengthen NATO’s Defense Planning

Weapon	Maximum Range	Launch Platforms	Russian Assets to Hold at Risk	Recommended Posturing in NATO’s Eastern and Northern Flanks
ATACMS	300 km	M142 High Mobility Artillery Rocket System; M270 Multiple Launch Rocket System	<ul style="list-style-type: none"> - Frontline airfields - Frontline SAM sites - Frontline command and control 	<ul style="list-style-type: none"> - Poland - Romania - Lithuania - Finland - Estonia
Taurus KEPD-350	500 km	Eurofighter Typhoon EF-2000; Saab JAS-39 Gripen (forthcoming)	<ul style="list-style-type: none"> - Fixed A2/AD infrastructure - Frontline SAM sites - Assets in Kaliningrad 	<ul style="list-style-type: none"> - Poland - Romania - Finland
Tomahawk Land Attack Missile (TLAM)	1,600–2,500 km	U.S. Navy <i>Arleigh Burke</i> -class destroyers; <i>Virginia</i> -class attack submarines	<ul style="list-style-type: none"> - Naval facilities - Assets in Kaliningrad - Assets in the Kola Peninsula 	<ul style="list-style-type: none"> - Baltic Sea - Norwegian/Barents Sea
Long-Range Hypersonic Weapon (“Dark Eagle”)	2,750 km	U.S. Army ground-mobile battery	<ul style="list-style-type: none"> - Strategic A2/AD nodes deep inside Russia - Strategic airbases - Bunkers - Strategic SAM headquarters 	<ul style="list-style-type: none"> - Poland - Romania - Lithuania

Source: Author’s analysis.

CONCLUSION

After the Cold War, Russia developed its novel nuclear weapons systems in response to both its own weakening conventional forces and advances in U.S. missile defenses and precision strike munitions. Putin has lauded these systems as “invincible” against any missile defenses. However, lessons learned from Ukraine demonstrate that at least some of the capabilities, namely Kinzhal and Tsirkon, may not be as invulnerable to interception as claimed. Furthermore, expert analyses suggest that these weapons—while faster and more maneuverable, possessing loitering capabilities—do not have significantly more strategic advantages than Russia’s legacy weapons, which already pose credible threats to assets in both North America and Europe. Fundamentally, the novel systems do not substantially change the strategic balance between Russia and the West.

Instead, Russian leadership primarily employs the novel capabilities for psychological warfare. Moscow could use more of these missiles to give a show of force intended to pressure the West to halt support for Ukraine or—in the context of a potential direct conflict between NATO and Russia—to coerce the alliance into surrendering.

Russia's nuclear arsenal is the largest and the most diverse in the world, maintaining a credible second-strike capability against Moscow's adversaries. Yet this capability already exists among Russia's legacy weapons, and the novel nuclear weapons systems do not grant it a decisive strategic or tactical edge. Therefore, while NATO should evaluate how best to deter Russian aggression, it should not be unnerved by these weapons. The alliance should instead adapt its defense planning to make itself more resistant to the Russian demands that might accompany further use of the novel capabilities in Ukraine or against a NATO member state.



Disruption

Examining the Practicalities of China's Nuclear Capability Breakout

By Shaquille James

INTRODUCTION

China's nuclear capability breakout may become the greatest disruption to the global nuclear landscape since the disintegration of the Soviet Union. Equally, as China's nuclear capabilities advance, debate rages on regarding the origins of and rationale for its sudden increase in nuclear capabilities. Despite the vast array of commentary, many unanswered questions remain about what China seeks to achieve with an expanded nuclear deterrent. There are a number of theories as to the cause of China's nuclear capability breakout, including national pride, nuclear blackmail, or legitimate national defense concerns.

While China's intentions are less than clear from a rhetorical or political perspective, there are other methods of interpreting the end goal of China's nuclear capability breakout. One such method is the close examination of what nuclear capabilities China chooses to develop and their potential implications for China's nuclear strategy generally. By examining China's—or any nation's—nuclear capabilities, it is possible to produce a set of nuclear objectives that the nation can or cannot accomplish. For example, a nation that cannot or will not carry out a disarming first strike against an adversary may still be able to deter that adversary with second-strike capabilities—a nuclear objective that could be revealed by a noticeable focus on second-strike-oriented capabilities as compared to first-strike-oriented capabilities. In China's case, a comparison of plausible Chinese nuclear objectives before, during, and after China's nuclear expansion could reveal a set of objectives that China is seeking to achieve.

This new set of objectives could offer strong capabilities-based insight into the rationale behind China's nuclear capability breakout. For example, if it reveals a significant increase in plausible nuclear objectives vis-à-vis the United States, China's nuclear capability breakout could plausibly be focused on offsetting U.S. nuclear capabilities. However, if China's nuclear capability breakout, instead, allows for a

significant increase in regional objectives and only a marginal increase in other objectives, then China's nuclear capability breakout may focus on factors other than the United States.

As such, this article aims to determine what nuclear objectives China can realistically achieve that were either impossible or unrealistic before its nuclear capability breakout. This exploration will demonstrate that while China has achieved a significant expansion of plausible nuclear objectives, most of these are the result of decades-old development programs in place long before China's nuclear expansion of the 2010s. Instead, the true hallmarks of China's nuclear expansion are the development of advanced—but perhaps not necessarily disruptive—nuclear-capable weapon systems, a significant expansion of China's nuclear weapons inventory, and a significant increase in the capacity to achieve nuclear objectives that were already achievable.

BACKGROUND: CHINA'S NUCLEAR CAPABILITY BREAKOUT

In 1984, China's stockpile of nuclear weapons reached its Cold War high-water mark of 249 warheads.¹ This was in comparison to the Soviet stockpile of 37,000 nuclear weapons and the U.S. stockpile of 21,000 nuclear weapons during the same year.² At the time, both the Soviet Union and the United States maintained nuclear triads and could deliver nuclear weapons via air-, sea-, and land-based assets. By comparison, China's considerably smaller nuclear inventory was limited to nuclear gravity bombs delivered by aircraft and crude, inaccurate intercontinental ballistic missiles (ICBMs) in the form of the liquid-fueled DF-4 and DF-5. Additionally, China did not possess a launch-on-warning (LOW) or launch-under-attack system, nor did it mate nuclear weapons to their delivery systems during peacetime.³ This posture—along with Chinese state policy established in 1964—essentially required nuclear detonations to occur on or above Chinese territory before China could launch a nuclear response.⁴ At this Cold War peak—particularly in comparison to other recognized nuclear states—China's nuclear capabilities were austere at best.

Fast-forward to 2025 and China's nuclear posture and capabilities are far more formidable than in 1984. In this paper, *nuclear capability breakout* refers to the sudden upsurge in Chinese nuclear capabilities, perhaps more significant than China's original nuclear breakout in 1964. The U.S. Department of Defense's 2024 China military power report estimates China's arsenal at over 600 operational nuclear weapons—more than double its Cold War high-water mark.⁵ Additionally, China's nuclear delivery platforms are now considerably more sophisticated and diverse. In addition to upgraded versions of the original DF-5 ICBM, China fields the DF-31 and DF-41 road-mobile ICBMs, which, according to reports, are more reliable, accurate, and reactive due to their use of solid rocket fuel.⁶ Although the DF-4 and DF-5 ICBMs were previously China's only silo-based ICBM weapon systems, China has constructed at least three additional ICBM fields, totaling well over 200 new

1 Robert S. Norris and Hans M. Kristensen, "Global Nuclear Inventories, 1945–2010," *Bulletin of the Atomic Scientists* 66, no. 4 (2015): 81, <https://doi.org/10.2968/066004008>.

2 Ibid.

3 U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2022* (Washington DC: U.S. Department of Defense, 2022), 64, <https://media.defense.gov/2022/Nov/29/2003122279/-1/-1/1/2022-MILITARY-AND-SECURITY-DEVELOPMENTS-INVOLVING-THE-PEOPLES-REPUBLIC-OF-CHINA.PDF>.

4 Tong Zhao, "Changes in and the Evolution of China's Nuclear Thinking," in *Understanding Chinese Nuclear Thinking*, eds. Li Bin and Tong Zhao (Washington DC: Carnegie Endowment for International Peace, 2016), 269.

5 U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2024* (Washington DC: U.S. Department of Defense, 2024), 101, <https://media.defense.gov/2024/Dec/18/2003615520/-1/-1/0/MILITARY-AND-SECURITY-DEVELOPMENTS-INVOLVING-THE-PEOPLES-REPUBLIC-OF-CHINA-2024.PDF>.

6 Ibid., 65.

silos.⁷ These silos represent a manifold increase in China's capacity to field silo-based ICBMs.

China's expansion of capabilities extends to other nuclear systems as well. It now fields a fleet of nuclear-powered strategic ballistic missile submarines (SSBNs) capable of launching the JL-2 and JL-3 submarine-launched ballistic missiles (SLBMs).⁸ Signs suggest that China fairly recently began at-sea deterrence patrols using its *Jin*-class SSBNs, which implies that China has begun to mate at least some nuclear weapons to their delivery platforms during peacetime—a practice it has historically avoided.⁹ In 2019, China also fielded the H-6N—a nuclear-capable bomber that represents the establishment of a Chinese strategic nuclear triad.¹⁰

Further, more changes are in store for China's nuclear capabilities. China is believed to be developing advanced weapon systems capable of delivering or transporting nuclear weapons. These future weapon systems include the Type 096 SSBN, the nuclear-capable H-20 stealth bomber, and a swath of hypersonic weapon systems assessed to be nuclear capable.¹¹ This is all in addition to China's 2021 test of what is believed to be a fractional orbital bombardment system (FOBS), which is also believed to be nuclear capable.¹²

What does this increase in China's capabilities mean for its nuclear strategy overall? What can China achieve now that it could not achieve before? And what does this say about China's nuclear intentions or ambitions? Answering these questions will require a close examination of China's nuclear capabilities in the past and present, as well as an assessment of what nuclear objectives it could realistically achieve with said capabilities.

METHODOLOGY FOR ASSESSING CHINA'S NUCLEAR CAPABILITIES AND OBJECTIVES

The assessment of Chinese nuclear capabilities is a fairly straightforward exercise, using open-source information on various aspects, including the number of operational Chinese nuclear weapons and delivery systems, how these weapon systems are deployed, and how and when these weapon systems were developed. Compiling this information every 10 years from 1984 to 2034 enables a comparative assessment of China's ability to achieve a list of 20 nuclear objectives. These include 13 standalone objectives and a scalable final objective that counts as a one nuclear objective for every nuclear-armed nation China achieves parity with or superiority over. For example, if China achieves five standalone objectives and maintains nuclear parity or superiority over three nations, then its total score would be 8 out of 20 objectives for that time period.

DEFINING ACHIEVABLE NUCLEAR OBJECTIVES

This research focuses on China's ability to achieve a list of nuclear objectives, derived from those commonly described by nuclear scholars, those specifically described by Chinese scholars and

7 Joby Warrick, "China Is Building More Than 100 New Missile Silos in Its Western Desert, Analysts Say," *Washington Post*, June 30, 2021, https://www.washingtonpost.com/national-security/china-nuclear-missile-silos/2021/06/30/0fa8debc-d9c2-11eb-bb9e-70fda8c37057_story.html; and Matt Korda and Hans Kristensen, "China Is Building a Second Nuclear Missile Silo Field," *Federation of American Scientists*, July 26, 2021, <https://fas.org/blogs/security/2021/07/china-is-building-a-second-nuclear-missile-silo-field/>.

8 U.S. Department of Defense, *Military and Security Developments 2024*, 56.

9 *Ibid.*, 104.

10 *Ibid.*, 59, 105.

11 *Ibid.*, 103–5.

12 *Ibid.*, 109.

the Chinese government, those eventually achieved by China, and those that represent common milestones for other nuclear-armed nations with whom China may pursue nuclear parity. Table 1 presents a list of these objectives and the criteria for achieving them.

Table 1: Nuclear Objectives

Nuclear Objective	Description
Nuclear strike capabilities	China is capable of launching a nuclear strike of any type.
Theater strike capabilities	China possesses nuclear assets capable of striking regional targets at intermediate distances (3,000–5,500 km).
Strategic strike capabilities	China possesses nuclear assets capable of striking strategic targets at intercontinental distances (5,000 km or more).
Countervalue strike capabilities	China is capable of attacking a target’s population centers with nuclear weapons.
Hard-target strike capabilities	China possesses nuclear assets with enough accuracy (<120 m CEP) to threaten hardened targets.
MIRV capabilities	China fields a nuclear delivery system capable of delivering MIRVs.
Credible nuclear second-strike capabilities	China possesses a nuclear asset capable of surviving a nuclear first strike and delivering a nuclear second strike.
Robust nuclear second-strike capabilities	China possesses more than one nuclear weapon system or leg of the nuclear triad capable of surviving a nuclear first strike and delivering a nuclear second strike.
Survivable at-sea deterrent	China possesses a sea-based nuclear deterrent capable of surviving a first strike and launching a second strike.
Nuclear triad	China possesses nuclear assets capable of delivering nuclear weapons from sea, air, and land.
Launch-on-warning capabilities	China is capable of launching a nuclear counterattack after detection of a nuclear attack and before or while nuclear detonations take place.
Hypersonic strike capabilities	China fields a nuclear weapon system with modern hypersonic capabilities (e.g., hypersonic speed, maneuverability).
Stealthy strategic bomber capabilities	China possesses a low-observable, nuclear-capable strategic bomber capable of penetrating enemy air defenses and delivering a nuclear payload.
Nuclear parity or superiority	China has a similar or greater number and variety of nuclear weapons and capabilities than a given nuclear-armed nation. This category represents up to seven objectives—one for each nation China has achieved parity with or superiority over.

Note: CEP = circular error probable; MIRV = multiple independently targetable reentry vehicle.

Source: Authors’ research.

This research utilizes assessments of Chinese nuclear capabilities beginning in 1984 to judge what nuclear objectives China could achieve in different eras. For example, if China did not possess nuclear-capable strategic bombers, submarines, and long-range missiles by 1984, then it did not achieve the nuclear triad objective in that era. Similarly, if China had the ability to launch a successful nuclear strike in 1984, then it achieved that objective. By performing the same analysis at 10-year intervals ending in 2034, trends in China’s nuclear capabilities can be tracked over time. Although it is clear that China’s nuclear capabilities have increased significantly, questions remain: How and in what manner have those capabilities grown, and what can China realistically achieve now that it could not before? Exploration of China’s nuclear growth trends and their characteristics offers insight into what nuclear capabilities China has prioritized over others, what capabilities have been a focus since the beginning of China’s nuclear capability breakout, and what objectives China may prioritize in the future.

ASSESSING NUCLEAR OBJECTIVES

Nominally, determining whether or not China is capable of meeting a particular nuclear objective should be fairly straightforward: If China has the requisite capability to meet the objective, then it should be noted as having met the objective with a simple yes or no. However, there can be difficulties in making this determination.

For starters, it is not always clear what capabilities China possesses. While there is much open-source information on China’s nuclear capabilities, blind spots remain. To offset this uncertainty, the responses yes (Y), no (N), and inconclusive (I) are used to assess each Chinese nuclear objective at each time interval.

Additionally, though China may appear to meet the condition for a particular objective on paper, the reality can be different. For example, China commissioned a nuclear-powered SSBN in 1983, but it is believed that this submarine never underwent a nuclear patrol.¹³ As a result, though China appeared to meet the requirements for achieving this objective, it had not yet truly developed this capability, meriting a “no” assessment.

An explanation of notable changes, exceptional circumstances, and quirks in the data follows each period assessment. At times, China achieved a nuclear objective but over time became capable of achieving that objective in a notably more robust and capable manner. In such cases, China’s capability is noted as improved and marked with the “+” symbol (Table 2). For the metric of nuclear parity/superiority, China was given a score from zero to seven, reflecting China’s degree of parity with or superiority to seven other nuclear-armed nations.

Table 2: China’s Achievement of Nuclear Objectives, 1984–2034

Nuclear Objective	1984	1994	2004	2014	2024	2034
Nuclear strike capabilities	Y	Y	Y	Y+	Y+	Y+
Theater strike capabilities	Y	Y	Y	Y+	Y+	Y+
Strategic strike capabilities	Y	Y	Y	Y+	Y+	Y+
Countervalue strike capabilities	Y	Y	Y	Y+	Y+	Y+
Hard-target strike capabilities	N	N	N	Y*	Y+	Y+
MIRV capabilities	N	N	N	Y*	Y+	Y+
Deploy credible nuclear second-strike capabilities	I	I	I	Y*	Y+	Y+
Deploy robust nuclear second-strike capabilities	N	N	N	Y*	Y+	Y
Deploy a survivable at-sea deterrent	N	N	N	Y*	Y+	Y
Deploy a nuclear triad	N	N	N	N	Y*	Y
Launch-on-warning capabilities	N	N	N	N	N	Y*

13 China Power Team, “Does China Have an Effective Sea-Based Nuclear Deterrent?,” *ChinaPower*, CSIS, last updated August 26, 2020, <https://chinapower.csis.org/ssbn/>.

Nuclear Objective	1984	1994	2004	2014	2024	2034
Hypersonic strike capabilities	N	N	N	N	Y*	Y+
Deploy a stealthy nuclear strategic bomber	N	N	N	N	N	I*
Nuclear parity or superiority	1 (India)	1 (India)	3* (India, Pakistan, United Kingdom)	4* (India, Pakistan, United Kingdom, North Korea)	5 (India, Pakistan, United Kingdom, North Korea, France)	5 (India, Pakistan, United Kingdom, North Korea, France)
Total number of objectives achieved	5	5	7	13	16	17
Nuclear warhead count	249	234	235	250	500	>1,000+

Note: I = inconclusive; N = no; Y = yes. Estimated number of operational warheads is included in the table for reference.

+ Increase in previously achieved capabilities.

* Change from the previous rating.

Source: Robbert S. Norris and Hans M. Kristensen, “Global Nuclear Inventories, 1945–2010,” *Bulletin of the Atomic Scientists* 66, no. 4 (November 2015): 81, <https://doi.org/10.2968/066004008>; U.S. Department of Defense, *Military and Security Developments Involving the People’s Republic of China 2023* (Washington, DC: U.S. Department of Defense, 2023), 111, <https://media.defense.gov/2023/Oct/19/2003323409/-1/-1/1/2023-MILITARY-AND-SECURITY-DEVELOPMENTS-INVOLVING-THE-PEOPLES-REPUBLIC-OF-CHINA.PDF>; and U.S. Department of Defense, *Military and Security Developments Involving the People’s Republic of China 2024* (Washington, DC: U.S. Department of Defense, 2024), 109, <https://media.defense.gov/2024/Dec/18/2003615520/-1/-1/0/MILITARY-AND-SECURITY-DEVELOPMENTS-INVOLVING-THE-PEOPLES-REPUBLIC-OF-CHINA-2024.PDF>.

RESULTS: CHARACTERISTICS AND TRENDS IN CHINA’S NUCLEAR CAPABILITIES

1984–2004: AUSTERITY AND STABILITY

Overall, the 1984–2003 period represents a time when China’s nuclear arsenal was as austere as it was stable—particularly in comparison to those of the United States or Soviet Union and even the United Kingdom or France.

Notably, China did not deploy a nuclear triad. According to reports, it could deliver nuclear weapons by way of only two primary methods—long-range missiles, such as the DF-4 intermediate-range ballistic missiles (IRBMs) and DF-5 ICBMs, and aircraft—though the aircraft were not strategic long-range bombers.¹⁴ Additionally, although China commissioned the first and only *Xia*-class SSBN in 1983, the SSBN did not partake in any deterrence patrols during its time in service—meaning China, despite having constructed an SSBN, did not deploy a survivable sea-based nuclear deterrent. Additionally, it did not observe an LOW posture; in fact, it observed the opposite. China tended to separate its nuclear weapons from their delivery platforms during peacetime, with some delivery

14 Missile Defense Project, “DF-4,” Missile Threat, CSIS, last updated April 23, 2024, <https://missilethreat.csis.org/missile/df-4/>; and Missile Defense Project, “DF-5,” Missile Threat, CSIS, last updated April 23, 2024, <https://missilethreat.csis.org/missile/df-5-ab/>.

platforms also remaining unfueled.¹⁵ Because of this posture, had China faced a sudden, massive nuclear attack, it is very dubious whether Chinese nuclear forces could have survived and delivered a counterattack. As a result, although China could theoretically launch a counterstrike, its ability to launch a credible nuclear second strike is assessed here as inconclusive.

This baseline for China's nuclear capabilities did not change much during the 1984–2003 period. The only notable changes in China's achievable nuclear objectives came due to events outside of China—namely, Pakistan's emergence as a nuclear-armed state and decreases in the United Kingdom's nuclear capability. Beyond this, negligible changes in the size of China's nuclear arsenal comprise the largest change in China's nuclear capabilities.¹⁶

These assessments do not, however, mean to imply there was no movement at all in China's nuclear theory or ambitions. In fact, several weapons and weapon systems that would later appear in China's capability portfolio—including the JL-1 and JL-2 SLBMs, DF-31/DF-41 road-mobile ICBMs, and *Jin*-class SSBN—were in development during or around this time and nearing completion by 2004. Thus, the seeds for China's later nuclear expansion were already planted decades before its arrival.

2005–2014: NEW CAPABILITIES FOR THE PLA

The year 2014 represents a major increase in Chinese nuclear capabilities and, subsequently, the first major increase in China's achievable nuclear objectives. As illustrated in Table 2, China's achievable nuclear objectives expanded from 7 to 13 out of 20—with China acquiring capabilities in the fields of credible second strike, robust second strike, a survivable at-sea nuclear deterrent, hard-target kill, and multiple independently targeted reentry vehicles (MIRVs). The baselines for these capabilities lie in the development and fielding of the DF-31 and DF-41 road-mobile ICBMs, the *Jin*-class SSBN, and improvements in the accuracy of Chinese nuclear delivery platforms.

Despite the seemingly sudden increase in capabilities, as alluded to previously, many of these new Chinese capabilities had been in development for decades before finally being fielded in the run-up to 2014. Perhaps the most notable example is the DF-31 road-mobile ICBM, which began development in 1985, was first showcased in 1999, and entered service in 2006.¹⁷ Similarly, *Jin*-class SSBNs began development in the 1980s before the first boat was commissioned between 2007 and 2010.¹⁸

The arrival of the DF-41 road-mobile ICBM in 2010, though similar to the DF-31 in its development timeline, represented a notable shift in Chinese nuclear capabilities for two reasons. First, according to available data, the DF-41 was China's first strategic nuclear weapon capable of threatening hard and deeply buried targets (HDBTs). This was in large part due to its greatly improved reported circular error probable (CEP) of 100 meters, which, if accurate, gives the missile a hard-target kill capability.¹⁹ Additionally, during this time frame, China became capable of equipping some of its long-range missile systems with MIRVs. While there is some debate as to whether the DF-41 or the DF-5B was

15 U.S. Department of Defense, *Military and Security Developments 2022*, 64.

16 Norris and Kristensen, "Global Nuclear Inventories," 82.

17 Missile Defense Project, "DF-31 (Dong Feng-31 / CSS-10)," Missile Threat, CSIS, last updated April 23, 2024, <https://missile-threat.csis.org/missile/df-31/>.

18 Hans M. Kristensen, "Two More Chinese SSBNs Spotted," Federation of American Scientists, October 4, 2007, https://fas.org/publication/two_more_chinese_ssbns_spotted/.

19 Missile Defense Project, "DF-41," Missile Threat, CSIS, last updated April 23, 2024, <https://missilethreat.csis.org/missile/df-41/>; and John F. Aherne et al., *Effects of Nuclear Earth-Penetrator and Other Weapons* (Washington DC: National Academies Press, May 2005), 30–51.

the first Chinese weapon system to become MIRV capable, China likely was capable of fielding MIRV-capable missiles by 2014.²⁰

The year 2014 is also the first time multiple capabilities converged to enable China to achieve a given nuclear objective. In this case, the fielding of both the DF-31/DF-41 road-mobile ICBMs and the *Jin*-class SSBN allowed China to achieve not only a nuclear second-strike capability but also a *robust* second-strike capability—meaning that China possessed more than one nuclear weapon system or legs of the nuclear triad capable of surviving a nuclear first strike and somewhat reliably delivering a nuclear second strike. While only one survivable weapon system could be sufficient to ensure a nuclear response, the presence of multiple systems—particularly systems associated with different legs of the nuclear triad—makes this capability more robust.

Interestingly, however, the total number of Chinese nuclear weapons did not appear to change significantly in this period. Whereas China possessed an estimated 230 nuclear warheads in 2004, that number raised only slightly to approximately 250 warheads in 2014.²¹ If these metrics are to be believed, then China’s nuclear advancements between 2004 and 2014 were seemingly focused on increasing the variety and sophistication of China’s nuclear delivery platforms rather than on increasing the size of China’s nuclear stockpile. Given the increased variety of weapon systems, however, it is possible that the composition of China’s nuclear arsenal also changed—meaning China may have produced more modern warheads for its newest weapon systems while retiring older warheads for more legacy weapon systems, such as the DF-4 ICBM. This could result in a composition shift within China’s nuclear inventory without a significant change in the total number of warheads.

Nevertheless, it is clear that the 2005–14 period saw a significant increase in the variety and sophistication of Chinese nuclear capabilities, which was then accompanied by an increase in China’s achievable nuclear objectives. Additionally, China gained one extra nuclear objective due to superiority over the recently nuclearized North Korea.

2015–2024: DOUBLING DOWN ON PREVIOUS EFFORTS

By 2024, China had made significant advances in its nuclear capabilities, raising its achievable nuclear objectives from 13 to 16 out of 20. This growth stemmed from the development of advanced systems, including the establishment of a strategic nuclear triad composed of silo-based and road-mobile ICBMs, *Jin*-class SSBNs, the nuclear-capable H-6N bomber, and hypersonic strike platforms.

Air-deliverable nuclear weapons have long been part of China’s arsenal. However, the H-6N, introduced in 2018, represented China’s first nuclear-capable strategic bomber equipped for long-range intercontinental missions. With this addition, China joined the United States and Russia as the only powers with a nuclear triad, though its overall capability remained far behind.

Perhaps more important was the deployment of the DF-17 medium-range missile equipped with a hypersonic glide vehicle (HGV) reported to be nuclear capable.²² This system enhanced theater-level nuclear strike options and could lay the groundwork for longer-range hypersonic weapons launched

20 Hans M. Kristensen, “Pentagon Report: China Deploys MIRV Missile,” Federation of American Scientists, May 11, 2015, <https://fas.org/publication/china-mirv/>.

21 Phillip Patton Schell and Hans M. Kristensen, “Chinese Nuclear Forces,” in SIPRI Yearbook 2014: Armaments, Disarmament and International Security (Oxford: Oxford University Press, 2014), 316, <https://www.sipri.org/sites/default/files/SIPRIY-B14c06sV.pdf>.

22 U.S. Department of Defense, *Military and Security Developments 2022*, 65.

from ICBMs or SLBMs. The DF-17 also marked one of the first times China fielded a nuclear capability before the United States, giving Beijing a rare technological edge.

Beyond these developments, China strengthened several existing capabilities. Expansion of DF-41 ICBMs increased China's ability to threaten hardened underground facilities, while the JL-3 SLBM and MIRV-capable DF-5B improved multiple warhead delivery options. The deployment of additional *Jin*-class submarines accompanied—and perhaps allowed—near-continuous at-sea deterrence patrols by the late 2010s, marking a departure from China's prior practice of de-mating warheads during peacetime and bolstering its second-strike credibility.²³

The most dramatic shift came in the size of China's nuclear arsenal. For decades, the stockpile remained steady at around 230–250 warheads. By 2024, however, estimates placed the arsenal at 500 warheads—more than double previous levels but still smaller than the arsenal of the United States or Russia.²⁴

This expansion was possibly driven by the large-scale construction of new ICBM silos. Historically, China maintained only a few dozen silo-based missiles, but the addition of 320 new silos across three fields increased capacity more than tenfold.²⁵ To make use of this infrastructure, a larger warhead inventory became necessary. Similar demands likely arose from new delivery systems like the DF-17, H-6N, and JL-3, as well as from MIRV-equipped platforms.

Taken as a whole, the decade from 2015 to 2024 reflects both continuity and change. China invested in novel systems, such as hypersonic weapons, while simultaneously expanding existing capabilities. By 2024, Beijing had fielded a significantly larger and more versatile arsenal, signaling a shift away from minimal deterrence toward a more robust and flexible nuclear posture.

2025–2034: ADVANCED CAPABILITIES AND REFINEMENT

While it is impossible to predict China's exact nuclear capabilities in 2034, current weapon development, projected arsenal growth, and long-term trends allow for at least some reasonable forecasts. China could realistically achieve two new nuclear objectives: an LOW posture and the deployment of a nuclear-capable stealth bomber.²⁶ An LOW posture would allow Beijing to launch a counterstrike while under attack. Given China's progress in early warning systems and the deployment of silo-based ICBMs—well-suited to an LOW posture—China will likely at least acquire this option by 2034. At the same time, China is developing the H-20 stealth bomber, expected to be nuclear capable.²⁷ If comparable to the U.S. B-2 or B-21, the H-20 would enable precision nuclear strikes deep behind enemy defenses without relying solely on standoff weaponry. However, as the H-20 has not yet flown, its operational debut by 2034 remains uncertain.

Beyond these, many projected advancements will strengthen existing capabilities rather than create new ones. By 2034, China is expected to field the Type 96 SSBN, enhancing the survivability of its sea-based deterrent, and expand deployment of the DF-27 IRBM, improving theater-level strike options. Similarly, ongoing improvements in delivery system accuracy and hardened target penetration will refine rather than transform Chinese nuclear objectives.

23 U.S. Department of Defense, *Military and Security Developments 2024*, 53; and U.S. Department of Defense, *Military and Security Developments 2022*, 96.

24 U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2023* (Washington DC: U.S. Department of Defense, 2023), 111.

25 U.S. Department of Defense, *Military and Security Developments 2024*, 101.

26 *Ibid.*, 107.

27 *Ibid.*, 61.

Certain developments will also depend on deployment choices. China could expand the number of MIRV-capable systems, but whether it actually deploys MIRVs on more missiles will depend on trade-offs involving range and accuracy. Similarly, second-strike reliability could be bolstered by mating more warheads to delivery systems during peacetime—a practice still somewhat foreign to China.²⁸

China may also pursue highly advanced technologies. A notable case is the FOBS, tested in 2021, which could provide unique global strike options. However, with no further tests since its debut, the program's future remains uncertain.²⁹

Despite steady modernization, China is unlikely to achieve nuclear parity with the United States or Russia by 2034. Even pessimistic projections estimate the size of its arsenal to be well below that of its main competitors. Nonetheless, in specific areas—such as hypersonic weapons or stealth bomber development—China could rival or even surpass its peers. Achieving true parity would require Beijing to expand its arsenal far beyond current projections and historical trends.

In sum, China's nuclear trajectory toward 2034 suggests incremental growth, selective breakthroughs, and greater diversity in delivery systems but not full parity with the largest nuclear powers.

NOTABLE OBSERVATIONS AND TRENDS, 1984–2034

Examining China's nuclear evolution over the course of five decades reveals a number of trends. First, China's nuclear capabilities and its achievable nuclear objectives remained relatively stable/stagnant for at least two decades (1984–2004). Although China's achievable nuclear objectives increased by two between 1994 and 2004, this was arguably due to circumstances outside of China: namely, the decline of the United Kingdom as a nuclear power and Pakistan's rise as a nascent nuclear-armed state. As a result, China's nuclear capabilities—and by extension its achievable nuclear objectives—remained largely unchanged for at least two decades. While there are a number of possible explanations, it seems plausible that a combination of technological shortcomings and a tacit acceptance of the security status quo played a major part. This tacit acceptance of the security status quo appeared to change when Chinese President Xi Jinping took power—about the same time China's technological capabilities enabled it to pursue more advanced weaponry. Placed in this context, it is no surprise that China's nuclear capabilities would begin to expand after the 1984–2004 window.

Second, China's estimated arsenal of nuclear weapons also remained largely stable for several decades—beginning to increase only in the latter half of the 2010s, ostensibly as part of China's nuclear capability breakout. Notably, the size of China's nuclear arsenal did not appear to change significantly, even following the significant increase in China's achievable nuclear objectives during the 2005–14 period. Despite a nearly twofold increase in achievable nuclear objectives, the size of China's nuclear arsenal increased only marginally—though this assumes that open-source reporting can be taken at face value. This marginal increase is also despite several new weapon systems coming online during this period, including the DF-31 ICBM, the DF-41 ICBM, the JL-1 and JL-2 SLBMs, and others.

A potential explanation for this is the interoperability between China's various nuclear weapons

28 "Chinese Nuclear Weapons, 2025: Federation of American Scientists Reveals Latest Facts on Beijing's Nuclear Buildup," Federation of American Scientists, March 12, 2025, <https://fas.org/publication/nuclear-notebook-china-2025/>; and U.S. Department of Defense, Military and Security Developments 2024, 63.

29 U.S. Department of Defense, *Military and Security Developments 2024*, 110.

and nuclear delivery systems. For example, it is believed that the DF-31 ICBM was developed jointly with the JL-2 SLBM, meaning that the two weapon systems may be similar enough to share nuclear loadouts.³⁰ If this were true, then the production of a new weapon system may not necessarily require an increase in the total number of warheads, as there could be a collective pool of available compatible warheads. It is also possible that China preempted the need for additional warheads by producing them ahead of time while, at the same time, decommissioning old weapons—such as those slated for the JL-1 SLBM. Under these circumstances, China could significantly change the composition of its nuclear forces, including adding new weapon systems, without significantly changing the size of its nuclear arsenal.

Third, many key changes in China's nuclear capabilities, which then led to changes in China's achievable nuclear objectives, were in development decades prior to their operational deployment. Examples include China's road-mobile ICBMs and SSBNs. This implies that at least some Chinese advancements in the 2000s and 2010s represent efforts that stretch back decades and are not necessarily recent developments or initiatives.

Fourth, the most significant jump in terms of raw achievable goals came between 2005 and 2014. The second-most significant jump came between 2015 and 2024. However, in terms of refining capabilities and further solidifying China's ability to achieve objectives, 2015–24 was more significant. In other words, between 2005 and 2014, China appeared to focus on new capabilities for achieving new objectives. Between 2015 and 2024, it focused primarily on doubling down on those established capabilities while, to a lesser extent, pursuing new objectives. At this point in its nuclear development, save for the size of its nuclear inventory, China was quickly approaching the point of diminishing returns in terms of nuclear development. Whereas China had a wide variety of nuclear capabilities to seek, by the 2015–24 window, this variety had shrunk considerably and primarily featured more advanced technologies and the daunting task of pursuing parity or superiority over Russia and the United States. That being the case, it is also possible that China's relative decrease in newly achievable nuclear objectives was more a matter of practicality than an outright decision by its leadership.

CONCLUSION AND IMPLICATIONS

A review of developments in China's nuclear capabilities between 1984 and 2034 reveals a complicated story of relative stagnancy, a sudden upsurge in capabilities, and then a sudden upsurge in both capabilities and capacity, with a noticeable focus on capacity in the later years of development. The primary focus of this research was to determine the intent behind China's mid-to-late 2010s nuclear capability breakout. When controlling for decades-old initiatives and focusing on changes unique to the period, it appears that the goal of China's nuclear capability breakout was less to achieve new nuclear objectives and more to greatly increase China's capacity to achieve what were, at that point, legacy objectives. For example, while China became capable of launching a robust nuclear counterattack only within the 2005–14 window, it became even more capable of doing so in the 2015–24 window. The same can be said for many of China's capabilities during this period, and based upon currently known Chinese weapons programs, this could continue to be the case through 2034 and beyond.

In other words, for the foreseeable future, should this trend hold, China will continue to become a more potent nuclear power but not necessarily one that will upend the nuclear balance with new and

30 Missile Defense Project, "DF-31."

destabilizing nuclear capabilities. It is worth noting that, prior to the major increase in capabilities during the 2005–14 window, China’s nuclear capabilities were remarkably austere and objectively insufficient to effectively deter a massive nuclear strike—at least from an outside perspective. China’s capabilities after this window, though more well-rounded, were still quite lackluster in comparison to those of the United States and Russia. Even now, despite significant growth in its nuclear capabilities and capacity, China’s nuclear forces still pale in comparison to those of the United States and Russia. Put another way, although China now possesses a greater degree of capacity to achieve a wider array of nuclear objectives, both the United States and Russia can do almost everything China can—and, often, far better. Given that China is unlikely to reach true nuclear parity by 2034, this will likely continue to be the case over the next decade.

There is one area of potential exception here: China’s ability to field a FOBS. Although China reportedly tested a FOBS in 2021, FOBS is not featured in this research. The primary reason for this is that it is still unclear whether China will truly develop, successfully test, and field a viable FOBS. It is also worth noting that FOBS is not a new technology. In fact, both the United States and the Soviet Union tested a FOBS during the Cold War, with only the Soviet Union opting to deploy a nuclear-armed FOBS in 1972. It is worth noting that the Soviet Union then opted to dismantle the system roughly 10 years later due to, among other reasons, a lack of value added over more traditional weapon systems. Simply put, just because a nation tests a particular weapon system does not mean it will field the system in any meaningful way.

Nevertheless, given the changes in China’s nuclear capabilities isolated to the nuclear capability breakout, the question as to *why* begs to be asked. Why, for example, did China double down on existing capabilities rather than pursue new capabilities that could give it an edge in a future conflict? Similarly, why does China ostensibly aim to possess 1,000–1,500 warheads when doing so does not grant it nuclear parity or superiority over Russia or the United States?

The answers to these questions and others will give much needed context to China’s nuclear development. Future research should consider these questions along with how their potential answers can and should influence strategic planning for China’s continued rise on the world stage. While determining the *what* behind China’s nuclear rise is important, it is just as important, if not more so, to determine the *why*. Future research should aim to focus on the potential *why* behind China’s nuclear rise. As the *what* and the *why* behind China’s nuclear breakout become clearer, future research should also revisit the question of Chinese nuclear objectives. It is possible that Chinese nuclear objectives differ from the nominal list of objectives used in this research.



Assessing China's Nuclear Modernization and Pursuit of Escalation Management Capabilities

By Eliana Johns¹

INTRODUCTION

China's ongoing and rapid modernization of its nuclear forces has raised questions about the drivers behind the buildup and whether China is changing its nuclear strategy. These questions are fueled by the fact that China has not officially addressed its expanding nuclear forces and retains strategic ambiguity about its doctrine and force posture. Through its nuclear modernization, China is increasing not only the number of U.S. targets it can hold at risk but also its threshold for tolerating a first strike. Further, some believe China could be moving away from its "no first use" (NFU) policy toward an acceptance of limited nuclear use on the battlefield, raising concerns in Washington about stability.² China, by contrast, likely perceives its military modernization as a stabilizing effort since its enhanced capabilities decrease the likelihood of a first strike against it.³ The lack of communications channels or history of interaction on arms control issues also puts China and the United States in uncharted waters in a competitive environment ripe for misunderstanding and worst-case thinking.⁴

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 - 2 Austin Long, "Myths or Moving Targets? Continuity and Change in China's Nuclear Forces," *War on the Rocks*, December 4, 2020, <https://warontherocks.com/2020/12/myths-or-moving-targets-continuity-and-change-in-chinas-nuclear-forces/>.
 - 3 Tong Zhao, *Political Drivers of China's Changing Nuclear Policy: Implications for U.S.-China Nuclear Relations and International Security* (Washington DC: Carnegie Endowment for International Peace, July 2024), 12, 18, <https://carnegieendowment.org/research/2024/07/china-nuclear-buildup-political-drivers-united-states-relationship-international-security?lang=en>.
 - 4 *Ibid.*, 49.

Drawing on existing research, translations of Chinese military and official documents, and open-source analysis of China's nuclear forces, this paper explores the question of whether China might be seeking to plausibly manage nuclear escalation past the threshold of nuclear use. The desire to control the scope and intensity of a conflict through credibly threatening and carrying out nuclear strikes against diverse target sets with varying degrees of intensity would have profound implications for China's nuclear strategy and relationship with the United States. From the output of Chinese strategic thinkers and observations on the ground, it seems that China's ongoing nuclear modernization does not necessarily demonstrate a clear shift away from its existing NFU, survivable counterattack, and retaliatory doctrine. While China's modernization allows for increased flexibility and implicit nuclear signaling, its written strategy, fielded systems, and command and control structure continue to emphasize crisis prevention over crisis management. However, its strategic ambiguity and reliance on dual-capable systems increase the risks of misinterpretation and inadvertent escalation in a conflict. A constructive path forward for U.S.-China relations requires increased transparency from both nations on nuclear declaratory policy and entangled systems to mitigate risks of inadvertent escalation or misunderstanding.

BACKGROUND

This section provides a brief but critical historical context for the formation of China's nuclear doctrine and how it has evolved over the years. China declared an NFU nuclear posture when it tested its first nuclear device in 1964 and has publicly reaffirmed that policy ever since. The NFU policy reflects the "active defense" guiding principle of the Central Military Commission (CMC), first articulated under Mao Zedong as "striking only after the enemy has struck," which entails accepting initial damage in a protracted war.⁵ In the 1980s and 1990s, China possessed only a few hundred nuclear weapons, and strategists became aware of a potential weakness in its ability to deter limited nuclear attacks against regional military targets.⁶ However, because leaders saw a U.S.-China conflict as unlikely and the disadvantages of nuclear weapons as too great, they decided to maintain a minimum level of nuclear forces under a strategy of self-defense, retaliation, and commitment to avoiding arms races.⁷

Following the Gulf War, China prioritized the pursuit of advanced information-age weapons, such as precision conventional missiles and cyberattacks, for coercive leverage to achieve limited political objectives without triggering nuclear war or expanding a conflict.⁸ Authoritative People's Liberation Army (PLA) sources regularly emphasize the value of conventional forces and nonmilitary capabilities, given the escalation dangers, lack of precision and flexibility, and risks of relying exclusively on nuclear weapons for deterrence and coercion, since the nuclear taboo and risk of nuclear retaliation

5 State Council Information Office of the People's Republic of China, *China's Military Strategy (2015)* (Washington DC: Jamestown Foundation, May 2015), <https://jamestown.org/wp-content/uploads/2016/07/China%E2%80%99s-Military-Strategy-2015.pdf>; and National Institute for Defense Studies (NIDS), *NIDS China Security Report 2021: China's Military Strategy in the New Era* (Tokyo: NIDS, November 2020), v, 6–7, https://www.nids.mod.go.jp/publication/chinareport/pdf/china_report_EN_web_2021_A01.pdf.

6 Zhao, *Political Drivers*, 28.

7 David C. Logan and Phillip C. Saunders, *Discerning the Drivers of China's Nuclear Force Development: Models, Indicators, and Data* (Washington DC: National Defense University Press, July 2023), 80, <https://ndupress.ndu.edu/Media/News/News-Article-View/Article/3471053/discerning-the-drivers-of-chinas-nuclear-force-development-models-indicators-an/>; and Fiona Cunningham, *Under the Nuclear Shadow: China's Information-Age Weapons in International Security* (Princeton, NJ: Princeton University Press, 2025), 93.

8 Cunningham, *Under the Nuclear Shadow*, 3, 133.

create a credibility problem.⁹ Chinese military writings have identified nonnuclear methods of strategic deterrence, including “network and EMS warfare,” as having effects that “can be as *powerful as a nuclear strike* to produce a powerful deterrent, and even directly achieve the objective of war.”¹⁰

As Chinese President Xi Jinping and his military planners aim to build a “world-class military” by 2050, part of the military development requires the rapid expansion of China’s nuclear forces, but there is almost no explanation about the implications or purpose of the growth.¹¹ The Chinese military continues to emphasize “active defense” at the core of its written strategic thinking, along with the need for a “strong system of strategic deterrence,” of which nuclear forces remain a central element.¹² Public discussions are ongoing among Chinese experts regarding what military and nonmilitary capabilities compose a sufficient strategic deterrent.¹³ Amid increasing tensions over Taiwan and the growing possibility of confrontation with the United States, Chinese strategists appear to be once again reconsidering deterrence requirements and discussing a departure from traditional strategic thinking about the disadvantages of limited nuclear conflict.¹⁴ If Beijing chooses to develop capabilities for proportionate nuclear retaliation against U.S. limited nuclear strikes to either deter limited nuclear attacks or end a nuclear conflict on favorable terms, this will represent a profound shift in Chinese nuclear strategy and the U.S.-China relationship.¹⁵

WHAT OBSERVERS CAN HEAR: DOCTRINE AND LITERATURE

Over the years, publicly available Chinese authoritative literature has discussed the utility of nuclear weapons for preventing crises and has provided examples for demonstrating resolve and implying the risk of escalation below the nuclear threshold.¹⁶ Since the early 2000s, PLA military science strategists have discussed the idea of “war control,” or controlling the pace and intensity of an armed conflict in all phases of peacetime, crisis, and wartime.¹⁷ China seeks to achieve control in crises before it leads to war by shaping its strategic environment through information dominance and by using a wide range of tools, including economic pressure, media influence, the expansion of military infrastructure, cyber activities, and psychological and legal tactics.¹⁸ In peacetime, national military

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- 9 Logan and Saunders, *Discerning the Drivers*, 72–73, 80; and Marcus Clay and Roderick Lee, *Unmasking the Devil in the Chinese Details: A Study Note on the Science of Military Strategy* (Montgomery, AL: China Aerospace Studies Institute, January 2022), 12, <https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/Other-Topics/2022-01-24%20SMS%202020%20in%20Perspective.pdf>.
 - 10 Xiao Tianliang, ed., *Science of Military Strategy* (Washington, DC: National Defense University Press, 2017), 228, quoted in Clay and Lee, *Unmasking the Devil*, 12 (Clay and Lee’s italics). In the United States, the term *strategic* is frequently used when referring to nuclear weapons, particularly in the context of strategic deterrence. In contrast, the Chinese military uses *strategic* to mean a vital element that can shape the course or outcome of a war.
 - 11 Edmund J. Burke, Kristen Gunness, Cortez A. Cooper III, and Mark Cozad, *People’s Liberation Army Operational Concepts* (Santa Monica, CA: RAND, 2020), 21, https://www.rand.org/content/dam/rand/pubs/research_reports/RR300/RR394-1/RAND_RRA394-1.pdf.
 - 12 China Aerospace Studies Institute, *In Their Own Words: Science of Military Strategy*, 2020 (Montgomery, AL: China Aerospace Studies Institute, January 2022), 133. <https://www.airuniversity.af.edu/Portals/10/CASI/documents/Translations/2022-01-26%202020%20Science%20of%20Military%20Strategy.pdf>; and Alison A. Kaufman and Brian Waidelich, *PRC Writings on Strategic Deterrence: Technological Disruption and the Search for Strategic Stability* (Arlington, VA: CNA, February 2023), 20, <https://www.cna.org/reports/2023/04/PRC-Writings-on-Strategic-Deterrence.pdf>.
 - 13 Kaufman and Waidelich, *PRC Writings*, 20.
 - 14 Zhao, *Political Drivers*, 28.
 - 15 Ibid.
 - 16 Chinese authoritative literature includes writings by military strategists and officers, which are written as a resource for the military but also often with foreign audiences in mind. It is important to note that examining these translated texts overlooks potential contrary perspectives within the PLA and broader government. Moreover, publicly available authoritative Chinese military sources, especially those covering nuclear strategy topics, are increasingly outdated.
 - 17 Burke et al., *PLA Operational Concepts*, 9.
 - 18 Daniel Shats, *Chinese Views of Effective Control: Theory and Action* (Montgomery, AL: China Aerospace Studies Institute, Sep-

power and strategic forces can “effectively shape the situation” and “deter the enemy from launching a war of aggression and nuclear attack,” serving as a crisis prevention and signaling mechanism.¹⁹ The 2015 and 2025 military parades commemorating the 70th and 80th anniversaries of the end of World War II, respectively, are examples of how China signals its commitment to safeguarding its interests in peacetime, reflecting the prioritization of crisis prevention over crisis management, as emphasized across literature and official statements.²⁰

For over two decades, the concept of “effective control” has been discussed in Chinese military literature in the context of combat and the battlefield.²¹ According to the 2020 *Science of Military Strategy*, “effective control of the war situation” is achieved by winning the initiative in war, coordinating between military and nonmilitary means, reducing the risk of war becoming destructive and drawn out, and improving the effectiveness of warfare by limiting diminishing returns.²² The text describes the role of strategic deterrence in the spectrum of war control as useful for delaying the outbreak of war, encouraging adversaries to make different choices, and securing initiative in the opening battle to establish a favorable position, if necessary.²³ There is, however, little in-depth discussion in publicly available literature on the potential for inadvertent escalation stemming from nuclear-conventional entanglement, strategic ambiguity, or implicit nuclear signaling. Chinese strategic texts caution against “turning small battles into big battles” and discuss the need to grasp “the critical point” at which the war transitions to unfavorable conditions that could result in “adverse chain reactions.”²⁴ However, the very actions that strategic texts suggest for effective control or deterrence signaling could backfire and provoke the adversary to escalate, especially if the message is not clearly understood or communicated.²⁵

For example, in the event of war, China’s nuclear NFU policy does seem to serve as a signaling mechanism. The PLA uses the phrase “lowering the nuclear coercion threshold” to denote a temporary shift of the NFU policy during a crisis for the purpose of “actively implementing nuclear deterrence against the strong enemy [the United States] to deter it from continuing [a] conventional strike on China’s major strategic targets.”²⁶ According to a 2004 PLA training manual titled *The Science of Second Artillery Campaigns*, the order for adjusting the nuclear threshold should be “nuclear coercion via public opinion and propaganda, nuclear coercion via demonstrating and creating impressions and

tember 2022), 29, <https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/Other-Topics/2022-10-03%20Effective%20Control.pdf>.

19 China Aerospace Studies Institute, *In Their Own Words*, 109, 387.

20 Bryan Frederick et al., *Managing Escalation While Competing Effectively in the Indo-Pacific* (Santa Monica, CA: RAND, November 2022), 55, https://www.rand.org/pubs/research_reports/RR972-1.html.

21 Lyle Morris, “China’s Views on Escalation and Crisis Management and Implications for the United States,” Asia Society Policy Institute, January 22, 2025, <https://asiasociety.org/policy-institute/chinas-views-escalation-and-crisis-management-and-implications-united-states>; Gregory Kulacki, trans., “An excerpt from Yu, Jin, ed. 2004. *Dierpaobing zhanyixue* [The science of second artillery operations], Beijing: People’s Liberation Army Press, 294–96,” Union of Concerned Scientists, September 19, 2024, <https://www.ucs.org/sites/default/files/attach/2014/09/Kulacki-Translation%20of%20Coercion%20section%209-22-14.pdf>; and China Aerospace Studies Institute, *In Their Own Words*, 248.

22 China Aerospace Studies Institute, *In Their Own Words*, 245–46.

23 *Ibid.*, 132.

24 *Ibid.*, 250, 265.

25 Burgess Laird, *War Control: Chinese Writings on the Control of Escalation in Crisis and Conflict* (Washington, DC: Center for a New American Security, April 2017), 20, https://s3.us-east-1.amazonaws.com/files.cnas.org/documents/CNASReport-ChineseDesescalation-Final_2023-06-13-155721.pdf.

26 Zhao, *Political Drivers*, 26; and Yu Jixun, ed., *The Science of Second Artillery Campaigns* (Beijing: PLA Press, 2004), 294, quoted in Nathan Beauchamp-Mustafaga, Elliot Ji, Alexis Dale-Huang, Cindy Zheng, Gregory Graff, and Dahlia Anne Goldfeld, *Denial Without Disaster—Keeping a U.S.-China Conflict over Taiwan Under the Nuclear Threshold* (Santa Monica, CA: RAND, November 15, 2025), 25, https://www.rand.org/pubs/research_reports/RR2312-3.html.

nuclear coercion via launch exercises.”²⁷ The text continues to say that, depending on the threat from the enemy, Beijing can “announce the intended targets of nuclear attack. This is the highest level of nuclear coercion.”²⁸ While this text is nearly 20 years old, other PLA writings repeat similar options for nuclear signaling as well as guiding principles for these operations.²⁹ These writings consistently discuss specific measures, such as demonstrating “combat readiness” and “firm determination” to make the threat of nuclear use appear credible to the enemy and deter further aggression, as emphasized explicitly by Xi.³⁰

While Chinese strategic thinkers have traditionally written that conventional conflict is unlikely to escalate to the nuclear level and that escalation to an all-out nuclear exchange is nearly impossible to control once the nuclear threshold is crossed, discussions about escalation management capabilities have become more common, especially following Russia’s threats of nuclear escalation during its war in Ukraine.³¹ The availability of new technology and investments in missile accuracy and sensing capabilities over the years has also led to increased willingness by Chinese strategists to consider risk manipulation and how both conventional and nuclear weapons can offer greater escalation flexibility.³² For decades, the PLA has negatively labeled nuclear war fighting and preemptive nuclear strikes as elements of an offensive nuclear strategy pursued by the United States that is both dangerous and irrelevant to actual battlefield scenarios.³³ Since the start of Xi’s expansive military reform in 2015, however, the People’s Liberation Army Rocket Force (PLARF) has started to use phrases equally emphasizing conventional and nuclear missiles and combat training in joint operations, as well as slogans such as “deter war, fight war, stop war, and win war” that divert from the traditional avoidance of war-fighting references.³⁴ Some Chinese scholars are beginning to highlight potential operational benefits of nuclear weapons for achieving tactical effects, discussing the concept of “war-fighting deterrence” under the assumption that the effects of nuclear use could be somewhat controllable and limit collateral damage (and thus escalation).³⁵

Discussions in Chinese military writings also increasingly promote the concept of “launch-under-attack” (LUA, or “early warning counterattack”) and emphasize its compatibility with the NFU policy.³⁶ Rapid response training during PLARF “survival protection” exercises and the development of improved early warning systems seemingly suggest preparation for an LUA or “launch-on-warning” scenario, though they are also likely measures for safeguarding retaliatory strike capabilities.³⁷

27 Kulacki, “Excerpt,” 4.

28 Ibid., 4.

29 Beauchamp-Mustafaga et al., *Denial Without Disaster*, 45.

30 China Aerospace Studies Institute, *In Their Own Words*, 134; and Li Yongfei, Zou Fei, and Zhang Liang, “火箭軍某導彈旅: “雙劍合璧”鍛造王牌勁旅” [A missile brigade of the Rocket Force: ‘Double Swords Combination’ forges an ace force] China Military Network - PLA Daily, August 24, 2022, <http://www.81.cn/zt/2021nzt/zxjpqjszyxwmzwbw/wmzzwbw/hjjml/10180455.html>.

31 Zhao, *Political Drivers*, 28; and Clay and Lee, *Unmasking the Devil*, 12, 48.

32 Cunningham, *Under the Nuclear Shadow*, 133; and Kaufman and Waidelich, *PRC Writings*, 37.

33 Zhao, *Political Drivers*, 24.

34 Ibid.; Major Zhong Yonghe, “中共「火箭軍」威懾能力之研究” [Research on the deterrence capabilities of the communist party’s “rocket force”], *Army Bimonthly*, August 2018, https://www.mnd.gov.tw/NewUpload/201808/p92-122_263835.pdf?m; and “深刻把握強國強軍面臨的新形勢新任務新要” [Deeply grasp the new situation, new tasks and new requirements facing a strong country and a strong military], China Ministry of National Defense, March 9, 2023, http://www.81.cn/jfbmap/content/2023-03/09/content_335157.htm?m.

35 Kaufman and Waidelich, *PRC Writings*, 18, 30, 37.

36 Tong Zhao, “Is China Changing Its Nuclear Launch Strategy?,” *Foreign Policy*, August 5, 2025, <https://foreignpolicy.com/2025/08/05/china-nuclear-weapons-launch-policy-strategy/>; and China Aerospace Studies Institute, *In Their Own Words*, 221.

37 Hans Kristensen, Matt Korda, Eliana Johns, and Mackenzie Knight, “Chinese Nuclear Weapons, 2025,” *Bulletin of the Atomic Scientists* 81, no. 2 (2025): 135–60, <https://www.tandfonline.com/doi/full/10.1080/00963402.2025.2467011>.

Preparing for LUA could be seen as a tool for crisis signaling and demonstrating credible assured retaliation, useful for strengthening deterrence but not necessarily indicating a departure from NFU.

Notably, China has historically not maintained warheads mated to delivery systems, meaning adopting LUA would require significant changes to China's nuclear posture as well as authority over the weapons themselves. Suggestions of China targeting military forces and infrastructure in nuclear war fighting or a nuclear counterattack would also require a major change in its strategy and employment guidance, not to mention warhead sizes, since China has historically prioritized inflicting "unbearable damage" to urban targets to achieve results with its limited nuclear forces.³⁸ While an increase in the PLA's public discussion about the potential value of both LUA and nuclear war fighting and the need to reduce collateral damage raises questions about potential changes in nuclear doctrine, there is little evidence to verify these shifts are taking place. Additionally, debates that took place in the past among Chinese strategists about the advantages of tactical nuclear weapons never resulted in a change from a retaliatory posture, and scholars today still highlight the risks that limited nuclear weapons pose to strategic stability.³⁹ The increase in discussion is certainly noteworthy, but further operational shifts through patrols and deployments of nuclear systems, nuclear warhead mating during peacetime, verifiable increased readiness of nuclear systems, or development of low-yield and short-range nuclear weapons could indicate an actual shift.

While there is growing reconsideration of the role of nuclear escalation management, it is not clear how strategic thinkers view proportional response in the context of escalation for both nuclear and nonnuclear actions. While Beijing has likely determined how to respond to situations such as a conventional attack on its nuclear forces, such strategy and planning is not made public, likely in an effort to strengthen deterrence through uncertainty.⁴⁰ Additionally, other than discussion of coercion and influencing an adversary's political will, there seems to be little public knowledge of how deeply Chinese strategic thinkers understand the value or application of crisis de-escalation. According to a National Defense University teaching text, crisis de-escalation takes place "when one side in a crisis expresses that it could accept the conditions put forward by the opponent, or the two sides through bargaining reach an agreement to compromise."⁴¹ For example, in the 1994 nuclear crisis between the United States and North Korea, "The two sides in the crisis equally recognized that the crisis's gradual escalation could lead to unbearable risks' and therefore sought negotiations."⁴² However, if one side does not see risk as unbearable or believes it can control and win the conflict even at a high price, the outcome may not be as certain. These significant uncertainties and a desire to "seize the initiative" may heighten the risk of misinterpretation and contribute to inadvertent escalation during a conflict.⁴³

WHAT WE CAN SEE: FORCE POSTURE

Historically, China's modernization has focused on improving missile accuracy and readiness, in part to safeguard the survivability of its "minimum deterrence" posture in response to enhanced

38 China Aerospace Studies Institute, *In Their Own Words*, 129; and Kaufman and Waidelich, *PRC Writings*, 24.

39 Cunningham, *Under the Nuclear Shadow*, 76, 87, 125.

40 Peter Wood, Alex Stone, and Thomas Corbett, *Chinese Nuclear Command, Control, and Communications* (Montgomery, AL: China Aerospace Studies Institute, March 2024), 6, <https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/PLARF/2024-03-11%20Chinese%20Nuclear%20Command%20and%20Control.pdf>.

41 Alison A. Kaufman and Daniel M. Hartnett, *Managing Conflict: Examining Recent PLA Writings on Escalation Control* (Arlington, VA: CNA China Studies, February 2016), 38, <https://www.cna.org/reports/2016/drm-2015-u-009963-final3.pdf>.

42 *Ibid.*, 38.

43 *Ibid.*, v.

U.S. conventional and nuclear forces.⁴⁴ For example, in the 1980s and 1990s, China's nuclear modernization began to emphasize more survivable road-mobile intercontinental ballistic missiles (ICBMs) in response to the deployment of U.S. Trident II D5 submarine-launched ballistic missiles (SLBMs) and a shift in U.S. ballistic missile defense strategy which threatened China's ICBM silos.⁴⁵ Additionally, after the United States withdrew from the Anti-Ballistic Missile Treaty in 2002, China felt compelled to respond to preserve the credibility of its limited deterrent, taking measures such as arming some of its ICBMs with multiple warheads.⁴⁶ Since rising to power in 2012, Xi has called for expansive reform and development across the PLA, including efforts to improve "strategic pre-positioning" and maintain "a high level of alert" during peacetime as well as wartime.⁴⁷ While the need for countermeasures against U.S. advanced capabilities has likely influenced the quality and number of delivery systems required under these guidelines, the pace and scale of China's nuclear modernization are unprecedented.

The addition of three new silo fields across the northern desert in China, for example, represents the sharpest-ever increase in China's nuclear arsenal. In addition to those 320 new silos, China has also added onto its existing liquid-fueled DF-5 ICBM force, which was designed with heavy throw-weights to carry massive nuclear payloads far distances. While the rationale for both these silo buildups may not be fully thought through internally, the most compelling motives are to demonstrate power and prestige; improve the ability to defeat missile defenses in a counterattack; and survive a first strike with enough force left to retaliate, ultimately dissuading an enemy from launching a strike in the first place.⁴⁸ Another underlying factor that might explain the ICBM expansion is that silos take less time to build than strategic ballistic missile submarines and are presumably easier to operate and faster to launch than road-mobile strategic systems. Additionally, the solid-fueled, silo-based DF-31BJ ICBMs have more operational benefits compared to the existing liquid-fueled DF-5s since they will have a safer, shorter, and less complex fueling process. Nevertheless, this expansion provides flexibility for China to accept more damage to its nuclear forces to strengthen its counterattack capabilities under its NFU policy.

China's motivations for establishing a nuclear triad are likely for the purpose of enhancing assured retaliation and for achieving great power status. The People's Liberation Army Air Force (PLAAF) currently possesses only one type of nuclear-capable bomber that can carry a nuclear-tipped, air-launched ballistic missile (though a new type of stealth bomber is being built).⁴⁹ However, these bombers do not allow China to target any additional sites it could not already hold at risk. While the intended purpose and role of China's expanded capabilities are unclear, they contradict the guideline of the "lean and effective" strategic nuclear force China has touted for decades.⁵⁰ Compared to other nations with "minimum deterrent" postures, such as the United Kingdom and France, an air leg seems

44 Hans Kristensen, Robert S. Norris, and Matthew G. McKinzie, *Chinese Nuclear Forces and U.S. Nuclear War Planning* (Washington, DC: Federation of American Scientists; Natural Resources Defense Council, November 2006), 50.

45 Ibid., 51; and Logan and Saunders, *Discerning the Drivers*, 70.

46 James M. Acton, "The U.S. Exit from the Anti-Ballistic Missile Treaty Has Fueled a New Arms Race," Carnegie Endowment for International Peace, December 13, 2021, <https://carnegieendowment.org/posts/2021/12/the-us-exit-from-the-anti-ballistic-missile-treaty-has-fueled-a-new-arms-race?lang=en>; Jing-Dong Yuan, "Chinese Responses to U.S. Missile Defenses: Implications for Arms Control and Regional Security," *Nonproliferation Review* 10, no.1 (2023): 91, <https://doi.org/10.1080/10736700308436918>; and Kristensen et al., *Chinese Nuclear Forces*, 18.

47 Gregory Kulacki and Robert Rust, "Xi Jinping's Thoughts on China's Nuclear Weapons," Union of Concerned Scientists, April 1, 2024, <https://blog.ucs.org/gregory-kulacki/xi-jinpings-thoughts-on-chinas-nuclear-weapons/>.

48 Zhao, *Political Drivers*, 9, 20.

49 Kristensen et al., "Chinese Nuclear Weapons," 135–60.

50 China Aerospace Studies Institute, *In Their Own Words*, 387.

excessive, especially when China has so heavily prioritized investments in ground- and sea-based nuclear asset survivability. But until the PLAAF establishes more sophisticated and capable nuclear air power with more graduated or limited strike options, this development suggests that China is seeking a new option for more tailored nuclear signaling or redundancy rather than a tool for nuclear escalation.

Notably, some experts have identified the DF-26 road-mobile ICBM, in particular, as an indicator that China is becoming more accepting of threatening nuclear escalation, potentially even moving away from its NFU policy toward acceptance of limited nuclear use.⁵¹ The DF-26 can carry a conventional or nuclear warhead, and reports of brigades training to transition between nuclear and conventional operations indicate that operators are preparing for an ability to swap the warhead types on the battlefield.⁵² Additionally, Chinese media reports describe the DF-26 as having a reentry vehicle capable of adjusting its trajectory during flight.⁵³ This feature would suggest that the missile may be capable of engaging moving targets, such as aircraft carriers, as well as achieving high-precision strikes against stationary targets.⁵⁴

These characteristics suggest an ability for the DF-26 to be useful for both nuclear signaling and escalation, whether through demonstrations with the conventional variant or low-yield nuclear strikes against adversary military targets. However, the larger context helps provide clarity on the likely intended role of the DF-26. As of 2025, the PLARF has likely completed phasing out both the nuclear and conventional variants of the older DF-21 road-mobile launcher and, in most cases, reequipping brigades with the DF-26.⁵⁵ The DF-26 is thus taking on the regional role that the older DF-21—and the DF-4, for that matter—played for holding Indian and Russian targets, as well as U.S. regional assets and allies, at risk.⁵⁶ It is therefore reasonable to assume the number of warheads assigned to the DF-26 force is in the same range as the DF-21. The system provides greater mobility and survivability for the PLARF while not drastically expanding the number of regional systems that are assigned a nuclear mission. The DF-26 also limits pressure to launch because it can conduct other missions if the PLA's sensors for moving targets are destroyed in an attack. This is a significant evolution from the conditions under which the antiship variant of the DF-21 operated, relying on vulnerable electronic intelligence satellite systems and fixed over-the-horizon radars along the coastline.⁵⁷

China's development of more accurate regional systems to replace older ones is consistent with its emphasis on the strategic value of precision strike weapons; it does not necessarily demonstrate a greater willingness to engage in nuclear escalation or limited nuclear exchange. Additionally, deploying a dual-use system like the DF-26 seems more efficient, and Chinese researchers have emphasized the operational advantages of conventional-nuclear entanglement. In describing motivations behind developing dual-use systems, some texts have explicitly noted

51 Long, "Myths."

52 Cunningham, *Under the Nuclear Shadow*, 174; and "[中国军队·核常兼备导弹部队] 东风浩荡 雷霆万钧 砥砺大国剑锋" [Chinese army: nuclear and conventional missile forces. The mighty and powerful Dongfeng sharpens the sword of a great power], CCTV.com, July 22, 2017, <https://military.cctv.com/2017/07/22/ARTISRzrXEL1cztsrXJ9rZSsw170722.shtml>.

53 Long, "Myths."

54 *Ibid.*; and U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2024* (Washington, DC: U.S. Department of Defense, 2024), 65.

55 U.S. Department of Defense, *Military and Security Developments*, 65.

56 Fiona S. Cunningham and M. Taylor Fravel, "Dangerous Confidence? Chinese Views on Nuclear Escalation," *International Security* 44, no. 2 (2019): 92, https://doi.org/10.1162/ISEC_a_00359.

57 Cunningham, *Under the Nuclear Shadow*, 158.

the “resource savings” that stem from dual-use forces and have praised the flexibility of the DF-26 in simultaneously augmenting both nuclear and conventional forces.⁵⁸ This aligns with the long-standing goal of the Second Artillery, and later the PLARF, to develop effective nuclear and conventional capabilities, as well as more survivable road-mobile ICBMs that strengthen retaliatory capability.⁵⁹

If China were to develop its nuclear escalation capabilities, the requirements would be shaped by how far it is prepared to ascend the escalation ladder and by the level of risk it is willing to accept of a nuclear confrontation expanding into all-out war.⁶⁰ China could decide to seek tactical and survivable strategic nuclear capabilities that would avoid “use-or-lose” pressures early in a conflict and carry out sophisticated and highly accurate limited nuclear operations to destroy adversary nuclear forces or missile defenses during a protracted nuclear war.⁶¹ However, plans for limited nuclear use would have to be accompanied by delegated command and control, as well as an ability to conduct damage limitation strikes or otherwise deter a retaliatory strike, to make the threat of limited nuclear use credible.⁶²

The lack of warhead mating during peacetime (and the uncertainty surrounding command and control operations for nuclear-armed, nuclear-powered ballistic missile submarine patrols) and the continued prioritization of survivable long-range systems, rather than short-range tactical systems, reinforce Chinese authoritative literature and official doctrine that maintain the NFU policy and question the utility of nuclear war fighting.⁶³ While the PLA has made changes in recent years to improve and intensify combat readiness procedures and joint logistics—aligning with requirements listed in strategic documents—it maintains a consistently high tolerance for accepting a first strike and strengthening an overwhelming counterattack capability.⁶⁴ While systems such as the DF-26 and air-launched ballistic missiles can offer flexibility for more tailored implicit nuclear signaling, China is likely aware of the dangers of misinterpretation and has not necessarily demonstrated a willingness or strategy for conducting limited nuclear strikes.

IMPLICATIONS

From these observations, there is little evidence to indicate a shift by China toward nuclear first use or engaging in nuclear escalation management past the nuclear threshold. Instead, the PLA is equipped to engage in varying levels of nuclear signaling short of nuclear use, which authoritative

58 David C. Logan, “Are They Reading Schelling in Beijing? The Dimensions, Drivers, and Risks of Nuclear-Conventional Entanglement in China,” *International Security*, 46, no. 22 (2020): 40, <https://www.tandfonline.com/doi/full/10.1080/01402390.2020.1844671>; and Andrew S. Erickson, “Academy of Military Science Researchers: ‘Why We Had to Develop the Dongfeng-26 Ballistic Missile’—Bilingual Text, Analysis and Related Links,” *Andrewerickson.com*, December 5, 2015, <https://www.andrewerickson.com/2015/12/academy-of-military-science-researchers-why-we-had-to-develop-the-dongfeng-26-ballistic-missile-bilingual-text-analysis-links/>.

59 Jing Zhiyuan and Zhang Haiyang, “二炮战略导弹部队: 由单一核部队向核常兼备发” [The second artillery strategic missile force: From a nuclear-only force to a nuclear-conventional force], *Chinanews.com*, June 8, 2011, <https://www.chinanews.com.cn/gn/2011/06-08/3095196.shtml>.

60 Zhao, *Political Drivers*, 28.

61 *Ibid.*, 29; and Cunningham and Fravel, “Dangerous Confidence?,” 69.

62 Cunningham and Fravel, “Dangerous Confidence?,” 75; and Cunningham, *Under the Nuclear Shadow*, 125.

63 David Logan, “The Dangerous Myths About China’s Nuclear Weapons,” *War on the Rocks*, September 18, 2020, <https://warontherocks.com/2020/09/the-dangerous-myths-about-chinas-nuclear-weapons/>.

64 State Council Information Office of the People’s Republic of China, “Full Text of 2019 Defense White Paper: ‘China’s National Defense in the New Era’ (English and Chinese Versions),” *Andrewerickson.com*, July 24, 2019, <https://www.andrewerickson.com/2019/07/full-text-of-defense-white-paper-chinas-national-defense-in-the-new-era-english-chinese-versions/>.

texts explain can be used to control the war situation or prevent one from occurring. However, bolstering the survivability of its nuclear forces may introduce escalation risks presented by Beijing's greater tolerance for absorbing both conventional and nuclear attacks.⁶⁵ Additionally, China's limited public discourse about its nuclear arsenal has simultaneously created a wide margin for implicit or explicit nuclear signaling below the nuclear threshold and a situation of heightened scrutiny that runs the risk of exaggerated interpretations. Thus, the United States should prepare to navigate a strategic landscape in which China seeks to manipulate risk at the margins, is highly tolerant of and prepared for conventional escalation, and is increasingly confident in its credible and survivable second-strike retaliatory capability. Additionally, the Pentagon has already indicated that China's entanglement of conventional and nuclear missile forces, such as with the DF-26, could "complicate deterrence and escalation management during a conflict" if a missile launch is "not readily identifiable."⁶⁶ This comingling creates additional escalation risks since it is unclear how China would respond if the United States inadvertently targets China's nuclear forces in a conflict.

If China plans to credibly shift its focus toward managing escalation through credible threats of limited nuclear use, its employment strategy and the types of systems it fields would likely change. For example, Beijing would probably develop systems that can threaten a broader variety of military and infrastructure targets with lower ranges of destruction than those that currently exist in its arsenal. It would also need to pursue production of new fissile material to enable this further expansion. Bearing in mind that theater-range missiles are not necessarily tactical in nature, nor do they imply a strategy for nuclear escalation management or engaging in limited nuclear war, these changes would nonetheless reflect a major shift in China's nuclear doctrine and would have profound implications for China's relationship with the United States as well as with other nations in the Indo-Pacific region. Further, if China were to establish nuclear escalation capabilities, Washington would likely suspect intent to use nuclear weapons first in a future conflict. The United States may respond by adding to its limited nuclear strike capabilities or enhancing its damage-limitation capabilities, which China could perceive as undermining its nuclear deterrent and thus could reinforce China's determination to strengthen its ability to manage escalation.⁶⁷

While policy debates in the United States focus on the stability risks of China's nuclear modernization, the path forward for risk reduction is strewn with obstacles. Chinese strategists view the moral prohibition against nuclear first use as strengthening strategic stability because it reduces the fear of surprise attack and the credibility of nuclear threats.⁶⁸ Thus, the declaratory policy of the United States and its refusal to acknowledge mutual vulnerability are viewed as not only destabilizing but also a double standard since U.S. nuclear doctrine touts transparency and predictability and calls for nuclear states to be "responsible custodians."⁶⁹ China, by contrast, has always seen the role of its nuclear arsenal as necessary to avoid perceived aggression and "bullying," deter its enemies from crossing the nuclear threshold, and bring China to a more prominent position on the world stage.⁷⁰ In recent years, Xi has argued that China is experiencing a significant change

65 Beauchamp-Mustafaga et al., *Denial Without Disaster*, 18.

66 U.S. Department of Defense, *Military and Security Developments*, 102.

67 Zhao, *Political Drivers*, 29.

68 David C. Logan, "Chinese Views of Strategic Stability: Implications for U.S.-China Relations," *International Security* 49, no. 2 (2024): 75, https://doi.org/10.1162/isec_a_00495.

69 U.S. Department of Defense, *2022 Nuclear Posture Review* (Washington, DC: U.S. Department of Defense, 2022), 2; and Zhao, *Political Drivers*, 43, 46.

70 Vipin Narang, *Seeking the Bomb: Strategies of Nuclear Proliferation* (Princeton, NJ: Princeton University Press, 2022), 164; and Burke et al., *PLA Operational Concepts*, 4.

to its threat environment, especially as the United States and its allies increasingly focus on China as a strategic rival.⁷¹ Faced with a worsening security climate, China has responded by increasing its secrecy and strategic ambiguity to enhance deterrence, viewing rising threats from the West as justification.⁷² However, this ambiguity hampers U.S. efforts to accurately assess China, making Washington more prone to worst-case assumptions.

Given these opposing views and tendencies to interpret actions through worst-case assumptions, increased transparency from both the United States and China is crucial for mitigating misperceptions and nuclear risks. For China, this could entail clarifying the relationship between its NFU pledge and its exploration of LOA concepts, as well as providing more transparency into the motivations and plans behind its nuclear modernization, especially given its adamant stance promoting nuclear disarmament. The United States, for its part, could communicate how new requirements, such as increased low-yield delivery options, are meant to reinforce deterrence and stability rather than signal intent to engage in nuclear war fighting. Both the United States and China should consider possible reactions or counteractions to measures they deem “stabilizing” and how exploiting the other’s insecurities could be more dangerous than de-escalatory.

CONCLUSION

China’s nuclear expansion has raised concerns in the United States that Xi has shifted the goals for China’s nuclear weapons program away from merely achieving “nuclear stability” with the United States toward a posture that could include greater reliance on nuclear coercion. China’s lack of transparency regarding its nuclear modernization and genuine distrust of U.S. intentions contribute to these concerns and heighten the risk of unintentional escalation, from both misinterpretation of actions and overconfidence in its ability to control escalation through coercive measures—a risk that is further exacerbated by dual-use systems such as the DF-26.⁷³ While there are implications for how the United States can think about its relationship with China and how China might use these systems in a contingency, it is important to consider that there may be no underlying strategic motivation or cohesive plan behind some of this modernization.

Additionally, leaders could make decisions in peacetime or in a contingency that do not align with the overarching strategy if they so choose. It is impossible to know how leadership may react in a crisis, but working toward a better understanding of China’s nuclear strategy and views on escalation management could enable the United States and China to take steps toward reducing the risks of escalation to nuclear use. Finally, assuming that war can be controlled or managed, especially beyond the nuclear threshold, overlooks the unpredictable nature of human behavior and state actions in conflict, as well as the inherent fallibility of even the most advanced technologies meant to control it.⁷⁴ This belief can lead decisionmakers in the United States and China to overestimate their ability to communicate intentions clearly or avoid miscalculation, fostering a dangerous sense of confidence that may contribute to unintended escalation.

71 Zhao, *Political Drivers*, 15.

72 Ibid., 49; and Logan, “Are They Reading Schelling?,” 38.

73 Zhao, *Political Drivers*, 50; and Cunningham and Fravel, “Dangerous Confidence?,” 106.

74 Laird, *War Control*, 16.



Nuclear-Armed Anti-Satellite Weapon Systems in Space

Implications and Escalation Dynamics

By Olivia Salembier¹

INTRODUCTION

In early 2024, reports emerged in the United States that Russia was working to develop a nuclear-armed anti-satellite (ASAT) weapon system to be placed in orbit.² According to experts and U.S. government officials, such a system would, if detonated, indiscriminately disable or destroy existing satellites and cause severe radiation damage in multiple orbits.³ Considering that the majority of satellites are not hardened to protect against the effects of a nuclear detonation and the radiation fallout, there would likely be significant impact on communications systems and the day-to-day functions that they enable on earth.

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 - 2 Patricia Zengerle, Steve Holland, and Jonathan Landay, "US Warned Allies about Russian Space, Nuclear Capabilities, Source Says," Reuters, February 15, 2024, <https://www.reuters.com/world/us/us-congressional-intelligence-chair-warns-serious-national-security-threat-2024-02-14/>.
 - 3 Victoria Samson, "Insight—FAQ: What We Know about Russia's Alleged Nuclear Anti-Satellite Weapon," Secure World Foundation, June 13, 2024, <https://www.swfound.org/publications-and-reports/insight---faq-what-we-know-about-russias-alleged-nuclear-anti-satellite-weapon>.

Space has become a highly contested domain, one that the West relies upon for both military and commercial functions. Russia, despite being a major space actor, does not rely on space assets to the same extent. As such, it likely seeks to exploit this asymmetry. The widespread impact that a nuclear detonation in space could have on military operations, particularly during a conflict, raises important questions: What escalation dilemmas could this capability pose for the West, and what can be done to deter and mitigate the risk of miscalculation?

When news broke about the possible development of this capability, it prompted extensive investigation and examination. However, after the initial reports, little news circulated about the issue until April 2025, when the COSMOS 2553 satellite—which analysts believe to be connected to Russia’s nuclear anti-satellite weapons program—appeared to be spinning uncontrollably, suggesting it may no longer be functioning.⁴ Despite this indication that Russia may be facing setbacks, the United States and its allies still must take seriously the implications such a program poses for their military operations in a conflict, how escalation dynamics would be perceived, and how they could affect decisionmaking.

The following analysis presents the history of nuclear weapons in space in order to contextualize the present circumstances. It details the physical effects of a nuclear detonation in orbit and the expansive implications on military and civilian functions. Further, it outlines the advantages that such a capability could provide Russia, specifically through its ability to create major dilemmas for its adversary (or adversaries) and heighten escalation and miscalculation within the space domain. This chapter explores two scenarios that demonstrate the complex escalation dynamics posed by such a capability, applying a framework to better assess this escalation. The analysis then proposes several response options, including enhancing diplomacy, bolstering space capabilities, and identifying the proper international channels for future decisionmaking on space issues that intersect with the nuclear realm.

NUCLEAR WEAPONS IN SPACE: A HISTORICAL OVERVIEW

The concept of placing nuclear weapons in space is not a new one. From 1945 to 1991, the U.S. military and the Soviet Union conducted high-altitude nuclear testing in outer space and had the ability to launch warheads into space on a long-range booster, such as an intercontinental ballistic missile, to conduct a high-altitude nuclear detonation.⁵ The most notable tests took place in 1962 during the Cuban Missile Crisis, when the United States conducted its Starfish prime test. The test took place at an altitude of 400 km (250 miles), crippling approximately one-third of the 22 satellites operating at that time—a figure that pales in comparison to the more than 10,000 satellites in orbit today.⁶ The Soviet Union also conducted its “K Project” high-altitude nuclear tests in 1961 and 1962, which aimed to prove the effectiveness of nuclear warheads for anti-missile applications. These tests allowed the Soviet military to determine the impact of nuclear detonations in space, particularly on the warheads of incoming missiles and on the performance of the Soviet anti-ballistic missile system that was being operated at the time.⁷ These tests ceased in 1963 with the enactment of the Partial Test Ban Treaty.

4 Clayton Swope, Kari A. Bingen, Makena Young, and Kendra LaFave, *Space Threat Assessment 2025* (Washington, DC: CSIS, April 2025), <https://www.csis.org/analysis/space-threat-assessment-2025>.

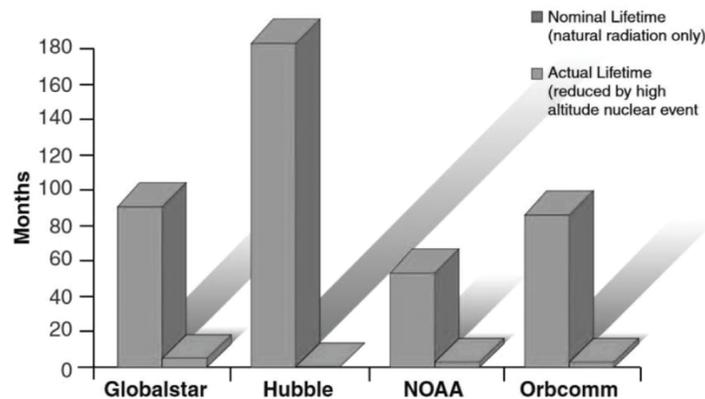
5 Defense Intelligence Agency, *Challenges to Security in Space: Space Reliance in an Era of Competition and Expansion* (Washington, DC: U.S. Department of Defense, 2022), https://www.dia.mil/Portals/110/Documents/News/Military_Power_Publications/Challenges_Security_Space_2022.pdf.

6 Geoffrey D. Reeves, Gian Luca Delzanno, and Quinn R. Marksteiner, *Earth’s Radiation Belts: The Hazards to Satellites and What Can Be Done to Mitigate the Risks?* (Los Alamos, CA: Los Alamos National Laboratory, 2020), <https://amostech.com/TechnicalPapers/2020/Atmospherics-Space-Weather/Reeves.pdf>.

7 Anatoly Zak, “THE ‘K’ PROJECT: Soviet Nuclear Tests in Space,” *The Nonproliferation Review* 13, no. 1 (2006): 143–150,

Despite the concerns and consequences posed by high-altitude nuclear tests, they have nonetheless provided detailed insights into the effects a nuclear detonation can have in orbit. These tests demonstrated that a nuclear detonation would emit no shockwave in space—contrary to a terrestrial detonation. Additionally, the detonation would blind any optical sensors pointed in its direction, the thermal pulse would overload and fry components on many satellites, and the electromagnetic pulse could damage satellite hardware and terrestrial electronics and power grids. The radiation from the detonation would be trapped by a Van Allen radiation belt, which forms when the Earth’s magnetosphere creates a zone of energetic charged particles, most of which originate from solar wind and are captured by and held around a planet by that planet’s magnetosphere. Van Allen radiation belts already create an environment that can degrade satellites, but in this case, the radiation from a detonation would be trapped for weeks or months, with the potential to degrade and destroy any satellites in multiple orbits, primarily in low Earth orbit (LEO). While the intensity of an expected high-altitude nuclear detonation radiation belt scales with nuclear yield, even modest yields have serious, long-term consequences.⁸ Figure 1 shows the expected lifetime, in months, for four different LEO satellites given the natural radiation belt environment (left bar) and with a high-altitude nuclear detonation belt produced by a 10-kiloton explosion (right bar). This further underlines the significant risks associated with a nuclear detonation in space, both for existing satellite infrastructure and for any replacements, as the surrounding environment would still create harmful effects.

Figure 1: LEO Satellite Expected Lifetimes



Note: Figure 1 shows the expected lifetime (in months) for four different LEO satellites given the natural radiation belt environment (left) and with a HANE belt produced by a 10 kT explosion (right).

Source: Donald H. Rumsfeld (Chair), *Report of the Commission to Assess United States National Security Space Management and Organization* (Washington, DC: Commission to Assess United States National Security Space Management and Organization, January 2001), 21, <https://aerospace.csis.org/wp-content/uploads/2018/09/RumsfeldCommission.pdf><https://aerospace.csis.org/wp-content/uploads/2018/09/RumsfeldCommission.pdf>.

CURRENT SPACE-BASED MILITARY CAPABILITIES

While counterspace capabilities and nuclear weapons in space are not a novel concept, today’s security environment makes their potential use incredibly dangerous. Several nations have conducted significant testing of a wide range of destructive and nondestructive space capabilities, and with

<https://doi.org/10.1080/10736700600861418>.

8 Reeves, Delzanno, and Marksteiner, *Earth’s Radiation Belts*.

it, challenged the international norms that have long prohibited the use of weapons of mass destruction in space. Space has dramatically changed since the 1960s and is now densely inhabited. As of May 2025, there were approximately 12,149 active satellites trackable in Earth's orbit.⁹ The majority of these satellites are in LEO, at an altitude stretching from 500 to 1,000 km. A smaller group of satellites resides in geostationary orbit (GEO), at around 36,000 km, each of which is always parked in one spot over the Earth's equator. Finally, an even rarer group resides in medium Earth orbit (MEO), between 5,000 and 15,000 km in altitude. Of the nations with the most operational satellites, the United States has over 8,000, Russia has over 1,500, and China over 800.¹⁰ As of March 28, 2025, Starlink, Space-X's satellite internet constellation, had 7,135 of its satellites in orbit.¹¹ This number illustrates the cross-cutting nature of the space domain on the commercial, civilian, and military sides and sheds light on the possible challenges that may arise in attempting to coordinate efforts between industry and government in the event of a conflict.

When it comes to space, the military and commercial sectors extensively overlap and in some cases are entangled, further illustrating the complications of overreliance on space-based assets. Perhaps a more challenging output of this dynamic is the creation of unwanted ambiguity between military operations and civilian functions. Russia has certainly perceived this reliance and likely seeks to exploit it. This highlights the importance of continuing to invest in evolving space technologies and capabilities while ensuring that redundancies are built into exercising and operations. Should space-based assets be compromised by an attack that would indiscriminately damage or destroy functions on the ground in a time of conflict, militaries must be ready to continue carrying out their functions through analog means.

A nuclear detonation in space would pose severe operational implications for military functions—conventional and nuclear—and would have overwhelming effects on civilian functions and societal resilience. Space is unique as an operational domain, with substantial differences between orbital and traditional warfare, yielding serious implications for the critical operational functions of modern militaries in conflict. There is also an interdependence between space and cyberspace, as space systems are responsible for providing critical global bandwidth. Current network architectures and information-sharing protocols underline that space capabilities rely on cyberspace.¹² This lends further support to the need to focus on multidomain operations.¹³

Space is a critical enabler, interconnected with the land, air, maritime, and cyber domains. Many of the critical capabilities military forces require during operations and logistics require and rely on space-based services. While existing counterspace weapons have been developed with the aims of degrading space services on a temporary basis and even destroying satellites permanently, the potential scale of destruction from a nuclear detonation in orbit would instantaneously degrade and destroy much of what has allowed modern militaries to have their edge. Some examples of critical capabilities that would immediately be degraded or lost include precision strike weapons; command and control architecture, including nuclear command, control, and communication (NC3); remote

9 "How Many Satellites are in Space?," Nano Avionics, May 4, 2023, <https://nanoavionics.com/blog/how-many-satellites-are-in-space/>.

10 Ibid.

11 Tereza Pultarova, "Starlink Satellites: Facts, Tracking and Impact on Astronomy," SPACE.com, March 28, 2025, <https://www.space.com/spacex-starlink-satellites.html>.

12 John J. Klein, "Space and Cyber Warfare as One," CSIS, *Commentary*, October 31, 2024, <https://www.csis.org/analysis/space-and-cyber-warfare-one>.

13 Andrea Gilli, Mauro Gilli, and Gorana Grgić, "NATO, Multi-domain Operations and the Future of the Atlantic Alliance," *Comparative Strategy* 44, no. 1 (2025): 73–91, <https://doi.org/10.1080/01495933.2024.2445491>.

sensing and intelligence, surveillance, and reconnaissance (ISR); the Global Positioning System (GPS); position, navigation, and timing (PNT); and satellite communications (SATCOM).¹⁴ Without these critical enablers, military effectiveness would be severely impacted in a conflict, which perhaps explains why Russia would choose to pursue such a capability.

In such a scenario, one cannot discount the gravity of the humanitarian toll a detonation would cause. There would be casualties to humans on board the International Space Station, but it would also cause fatalities and casualties on Earth and on airborne aircraft due to the electromagnetic pulse (EMP). For example, a nuclear explosion at an altitude of 100 km (62 miles) would expose 4 million square kilometers (about 1.5 million square miles) of Earth's surface beneath the burst to a variety of EMP effects.¹⁵ International norms would also be shattered, and the nuclear taboo would be broken, further undermining existing arms control and nonproliferation architecture—chiefly the 1967 Outer Space Treaty. Furthermore, the effects of a detonation would not discriminate, affecting space-faring adversaries and allies alike. Such an act can have substantial international implications, so it is worth examining why Russia might make such a choice.

WHAT ADVANTAGES DOES RUSSIA GAIN FROM FIELDING A NUCLEAR-ARMED ASAT?

The Russian COSMOS-2553 satellite is likely a mock-up of this ASAT capability. The satellite is in a circular orbit of about 2,000 km (1,240 miles) at the farthest edge of the LEO belt, which is unusual because the area is largely devoid of other systems. However, it began spiraling out of its usual position in April 2025.¹⁶ Some experts have theorized that this orbit would be safer for satellites should they be carrying a dangerous nuclear payload, as it would be less likely to be struck by debris or another satellite.¹⁷ Though this is only a supposed mock-up satellite for the capability, if an actual nuclear-armed ASAT was placed at this altitude, it would not immediately hit many satellites should it detonate. Despite this, the capability is sitting in a band of radiation where a detonation could have a long-term effect in LEO and affect multiple orbital regimes. This raises several questions: Why would Russia create a dedicated space-based nuclear capability when it could choose to use a ground-launched nuclear weapon instead? What advantage does Russia gain by fielding such a capability? While it is next to impossible to ascertain the Kremlin's calculus for such a decision, there are several plausible factors.

First, the idea of space-based nuclear weapons is not new; it was explored by Soviet leaders starting in the 1960s and particularly during the 1980s, when they were concerned about growing U.S. technical advantages in missile defense.¹⁸ The Russian development of this capability likely predates Russia's invasion of Ukraine in 2022; it was launched mere weeks before the invasion.¹⁹

14 Defense Intelligence Agency, *Challenges to Security in Space*.

15 Government Printing Office, *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack. Critical National Infrastructures* (Washington, DC: Government Printing Office, 2008), <https://apps.dtic.mil/sti/pdfs/ADA484672.pdf>.

16 Theresa Hitchens, "Is Russia's Cosmos 2553 Satellite a Test for a Future Orbital Nuclear Weapon?," *Breaking Defense*, May 22, 2024, <https://breakingdefense.com/2024/05/is-russias-cosmos-2553-satellite-a-test-for-a-future-orbital-nuclear-weapon/>; and Swope, Bingen, Young, and LaFave, *Space Threat Assessment 2025*.

17 Ibid.

18 Austin Long, "Red Glare: The Origin and Implications of Russia's 'New' Nuclear Weapons," *War on the Rocks*, March 26, 2018, <https://warontherocks.com/2018/03/red-glare-the-origin-and-implications-of-russias-new-nuclear-weapons/>.

19 Marc Berkowitz and Chris Williams, *Russia's Space-Based, Nuclear-Armed Anti-Satellite Weapon: Implications and Response Options* (Arlington, VA: National Security Space Association, 2024), <https://nssaspace.org/wp-content/uploads/2024/05/Russian-Nuclear-ASAT.pdf>.

Russia is likely seeking a capability that could destroy the large-scale satellite constellations used for communications and ISR, particularly to degrade the effectiveness of Ukrainian defense forces that heavily rely on commercial satellite communications and imagery.²⁰ Particularly in light of the success Ukraine has had in repelling Russian aggression in its use of satellite constellations through Starlink, Russia may also view the deployment of such a space capability as a source of leverage in its ongoing war in Ukraine and in any future potential conflict with NATO.²¹

Second, it is clear that Russia perceives the West to be overly reliant on space-based capabilities, both militarily and societally. In 2024, the United States launched 2,221 satellites, while Russia only launched 60.²² In particular, Russia believes that space is a domain where the United States could be coerced due to its reliance on vulnerable space systems.²³ Although the use of such a capability would also damage its own space-based assets, it would provide Moscow with new warfighting and deterrence options. In light of growing space threats, the United States has gone to great efforts to emphasize and harden its proliferated space constellations and its hybrid architectures in LEO, and Russian defense planners are keenly aware of this fact. While proliferation may be an effective passive countermeasure against kinetic energy ASAT weapons, Russia's development of this nuclear capability would render this ineffective. Critically, Russia knows that possession of a nuclear-armed ASAT would pose complicated dilemmas and challenges to the United States and its allies in deterring the launch of such a capability, managing new escalation dynamics, and, if needed, devising a response.

SCENARIOS FOR CONVENTIONAL-TO-NUCLEAR ESCALATION IN SPACE AND RELATED RISKS

While the gravity of the consequences and implications from the deployment and detonation of a Russian nuclear-armed ASAT are evident, what remains unclear are the resulting escalatory dynamics posed by such a dilemma. These escalatory dynamics are crucial to understand, particularly as they concern decisionmaking and the ability to devise response options. Some researchers have undertaken work in order to assess how these developments in space could affect escalation dynamics through various frameworks, with the intent to inform measures to reduce risk. One such framework put forth by researchers at the Stockholm International Peace Research Institute (SIPRI) looks at four key parameters to identify conditions in which an attack on a space system could lead to escalation: (1) the target of the attack; (2) the capability used in the attack; (3) the effect of the attack; and (4) its consequences.²⁴ While these are only baseline parameters and are not all-encompassing, they provide a starting point toward building a common understanding of the risks of escalation among space users, which has historically been lacking. This is particularly important, as one actor's response could have reverberating consequences for other actors in space (i.e., the United States, Russia, China, and others).

This framework can be applied to several escalatory scenarios that illustrate the dilemma Russia's nuclear-armed ASAT capability poses. The following two scenarios seek to illustrate the complexities

20 Aaron Bateman, "Why Russia Might Put a Nuclear Weapon in Space," *Foreign Affairs*, March 7, 2024, <https://www.foreignaffairs.com/russian-federation/why-russia-might-put-nuclear-weapon-space>.

21 James M. Acton, "Space Nukes Are Bad," Carnegie Endowment for International Peace, *Commentary*, October 8, 2024, <https://carnegieendowment.org/posts/2024/10/russia-space-nukes-bad?lang=en>.

22 Clayton Swope and Makena Young, "Is There a Path to Counter Russia's Space Weapons?," CSIS, *Commentary*, June 28, 2024, <https://www.csis.org/analysis/there-path-counter-russias-space-weapons>.

23 Berkowitz and Williams, *Russia's Space-Based*.

24 Nivedita Raju, "Parameters to Assess Escalation Risks in Space," Stockholm International Peace Research Institute, Research Policy Paper, February 2025, <https://doi.org/10.55163/edtc6801>.

that are tied to conventional space attacks and how easily these can escalate to the nuclear threshold. Specifically, the two scenarios contrast the difference in possible U.S. response options in a conflict with Russia centered on the space domain. One aims to capture the complexities already posed by the dual nature of many space-based capabilities. The second aims to capture the augmented complexity should there be a verified presence of a Russian nuclear-armed ASAT in orbit.

SCENARIO A: THE ENTANGLEMENT CHALLENGE

The United States and Russia both have dual-use satellites that are employed for nuclear and conventional operations, such as the United States' Space-Based Infrared System missile warning satellites. The primary mission of these satellites is to detect a nuclear launch, but they still have conventional roles. There are also advanced high-frequency communications satellites that would be used for transmitting orders to use nuclear weapons. These satellite capabilities are found in two different orbits, LEO and GEO, and are vulnerable to highly maneuverable co-orbital satellites.²⁵ In this scenario, Russia *does not* possess or field a nuclear-armed ASAT capability in orbit. This scenario supposes that in a conventional conflict between the United States and Russia, U.S. dual-use space capabilities come under a Russian kinetic attack intended only to degrade conventional satellite capabilities, which in turn results in undermining critical U.S. NC3 systems due to their dual use and vulnerability to nonnuclear attacks, presenting the “entanglement challenge.”²⁶ With a breakdown in communications channels, there is no Russian messaging to provide any clarity on the attack, which could then be perceived within Washington as escalation toward nuclear war. Factoring in the widespread lack of coordination between national and private actors when it comes to dealing with accidents in space, along with the convoluted role and obligations of the private sector, the situation at hand can be misperceived by the United States, leading to heightened escalation and an increased risk of moving toward the nuclear threshold.

Table 1: Scenario A: Conventional Conflict in Space—The Entanglement Challenge

Target	Capability	Effect	Consequences
U.S. proliferated satellite architecture	Nonnuclear kinetic attack	Unintended consequences to U.S. NC3 systems	U.S. perception of escalation into the nuclear threshold heightens decisionmaking risk, creating further instability

Source: Author's analysis.

When applying the four-prong framework (from SIPRI) to this scenario, the table for Scenario A shows that the target becomes convoluted due to the dual-use nature of certain satellites. While the conventional nature of the attack on the satellite may indicate that its intention was not to escalate to the nuclear threshold, the “fear of the unknown” may lead to misperceptions and false assumptions of the adversary, and could increase reluctance to respond. The attack would have effects on NC3, which could have massive consequences on both decisionmaking and operational ends. This scenario provides one instance of how the conventional and nuclear elements are deeply entangled in the space domain and require due consideration when unpacking escalation dynamics to inform decisionmaking.

25 Anya L. Fink, “Defense Primer: Nuclear Command, Control, and Communications (NC3),” Congressional Research Service, IF11697, August 15, 2025, <https://www.congress.gov/crs-product/IF11697>.

26 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 (2018): 56–99, https://doi.org/10.1162/isec_a_00320.

SCENARIO B: DELIBERATE CONVENTIONAL ATTACK

In this scenario, Russia has developed and is currently wielding a nuclear-armed ASAT capability that has been verified to have been in orbit. This scenario supposes that in a U.S.-Russia conflict, Russia deliberately targets through conventional means portions of the U.S. proliferated infrastructure in order to gain military advantage and degrade U.S. battlefield abilities. In doing so, some on-the-ground U.S. command and control systems are affected, which immediately escalates the nature of the conflict, as it is unclear whether this was an intended result of the attack. In assessing its response, the United States feels constrained in its decisionmaking due to the deterrent effect of Russia's nuclear-armed satellite capability. The U.S. decisionmaking calculus recognizes that actions would either need to remain under the conventional threshold or risk further escalation to the nuclear threshold, which could surpass the proportionality factor. The Russian capability inherently has loitering value that creates a constant instability mechanism, posing a danger to other capabilities in orbit, and presents an escalation dilemma for the United States to contend with.

Table 2: Scenario B: Conventional Conflict in Space—The Deterrent Value of a Nuclear-Armed ASAT

Target	Capability	Effect	Consequences
U.S. proliferated satellite architecture providing critical support to military operations	Nonnuclear kinetic attack; deterrent effect of a nuclear-armed ASAT	United States constrained in its ability to respond militarily	Creates an escalation dilemma for the United States; raises the stakes for conflict escalating to nuclear threshold

Source: Author's analysis.

When applying the four-pronged framework to this scenario, the table for Scenario B shows that Russia's target and the capabilities used for its means of attack are both conventional in nature and achieved their desired military effect. However, the sheer existence of the nuclear space capability poses challenges for Washington's ability to select a target that Russia would not perceive as unnecessarily escalatory. This demonstrates that the capability not only creates a deterrent effect but also poses escalation consequences for both Russia and the United States.

OPTIONS

In examining the implications of such a deployment, the widespread effects of a nuclear detonation in orbit, and the inherent escalation risks, several things become clear when considering potential courses of action. First, the primary aim for the United States should be to deter any further development and launch of such a capability. There will be few options for response once such a capability is deployed in orbit, and verification prior to launch would pose a great challenge. Once in orbit, the capability would create a use-or-lose dynamic, which—coupled with the fast-paced nature of the capability and little to no warning time—complicates response times and decisionmaking, as demonstrated in the scenarios. However, the sheer notion of the potential nuclear weaponization of space begs several considerations for the United States and its allies.

INTERNATIONAL REGIMES AS A DETERRENT?

The United States has made many public statements and engaged on this issue regularly, notably in early 2024. However, since then there has been very little official information on the capability, which may have caused ambiguity and a lack of credibility of such a threat. If the United States wants the

international community to continue taking the threat seriously and to respond with greater urgency, it could release more declassified, publicly shareable information on the issue. The United States and its allies, both within NATO and in the Indo-Pacific, could also further facilitate intelligence sharing and public education on the threat of such a deployment.

It is also important to consider the role China would play in such a scenario. Amid the initial panic generated following the U.S. statements about the Russian nuclear-armed orbital capability, China was promptly put under the microscope. China has invested substantially in both its military and civilian space capabilities and would be impacted should Russia employ this capability. While many have touted China's potential role in preventing Russia from any future employment of this capability in space, China will more likely continue to disengage from forms of arms control.²⁷ China abstained on the U.S.-Japan efforts in the United Nations that proposed a resolution that would reaffirm the nuclear space weapons ban; it did, however, join with Russia, which vetoed the resolution, to propose a stricter amendment that went further than the U.S.-Japan proposal, calling not only for efforts to stop weapons from being deployed in outer space but for preventing "for all time . . . the threat or use of force in outer space."²⁸ China's chief priority will likely be to maintain its own counterspace arsenal, and in the current political and economic climate, it is unlikely to give the United States any symbolic diplomatic wins. Despite this, U.S. officials have stated that they have discussed Russia's development of a nuclear-armed ASAT with China and India.²⁹ As a whole, an international agreement that would ban nations from possessing counterspace weapons would, in theory, be the most effective way to preserve security in space. However, amid the current international arms control climate and a lack of consensus on how to define a counterspace weapon, this would be highly unrealistic.³⁰

In considering the widespread implications of a nuclear weapon being detonated in space and the many actors that would be severely impacted, it is challenging to establish the right forum to hold such discussions and determine which actors should be at the table. Historically, high-level nuclear matters have been discussed within the UN Security Council and its permanent five members: China, France, Russia, the United Kingdom, and the United States, otherwise known as the P5. However, this may no longer be the right platform. Some members of the P5 have preferred to limit the forum to discussions of matters related to nuclear posture and the Treaty on the Non-proliferation of Nuclear Weapons (NPT), and not for space, cyber, and hybrid issues. This is how several members, China in particular, seem to have classified the issue of a Russian nuclear-armed ASAT. There is also a lack of shared views of these systems among the P5, which may further lead to miscalculation, as states rely on and use space differently based on their postures and priorities.³¹ In light of the growing cooperation in space among Russia, China, Iran, North Korea, and India, the P5 may not be a conducive format going forward, and thus new forums and channels must be explored for discussion of space concerns.

27 Swope and Young, "Is There a Path."

28 U.S. Mission to the United Nations, "Joint Statement on Behalf of the United States and Japan on the Draft Security Council Resolution on Weapons of Mass Destruction in Outer Space," press release, April 19, 2024, <https://usun.usmission.gov/joint-statement-on-behalf-of-the-united-states-and-japan-on-the-draft-security-council-resolution-on-weapons-of-mass-destruction-in-outer-space/>; and "Russia Vetoes Security Council Draft Resolution on a Weapon-Free Outer Space," UN News, April 24, 2024, <https://news.un.org/en/story/2024/04/1148951>.

29 "The Nuclear Option: Deciphering Russia's New Space Threat," CSIS, event transcript, May 3, 2024, https://csis-website-prod.s3.amazonaws.com/s3fs-public/2024-05/240503_Stewart_Nuclear_Option.pdf?VersionId=hon7HsECEKMjm.8UN-5ke388twAnyfWij.

30 Swope and Young, "Is There a Path."

31 Raju, *Parameters to Assess*.

NATO and the European Union have the potential to serve as leading forums to discuss and make decisions on the future of securing space in a Western context, while recognizing that they do not comprise many of the main actors in space. With Russia's invasion of Ukraine in 2022, NATO's return to collective defense has involved a rethink of its approach to space. NATO's Overarching Space Policy from 2019 could be updated or even renewed to reflect the current security environment and publicly lay out its ambitions and way forward within the space domain.³² Its recent Commercial Space Strategy will allow the alliance to further tap into the technological advancements in space within the private sector.³³ The European Union has also become further entrenched with these technological advancements. In 2024, it put forth the EU Space Strategy for Security and Defense, which aims to protect its space assets, defend its interests, deter hostile activities in space, and strengthen its strategic posture and autonomy, with a keen focus on the private defense sector.³⁴ As the conversation continues shifting to Europe taking responsibility for its own defense, this is particularly true of space capabilities. The European Union has a role to play in leading further development of European space capabilities, but doing so in a way that does not undermine the ongoing work NATO is doing to advance its deterrence and defense. Given that future work to advance Europe's role in space will rely heavily on industry, capability development, and procurement, the European Union should also remain open to non-EU allies participating in these works, as they are rooted in shared goals and values.

NATO in particular finds itself in a prime position to serve as a dedicated forum on space security issues, mainly relating to nuclear conflict in space, as it already has a dedicated body to discuss nuclear matters. Though NATO's most recent summit statement was incredibly brief and had no mention of space or nuclear issues, it did focus on the need to urgently spend more to reach its capability targets, including space capabilities.³⁵ In future defense ministerials or summits, NATO could consider discussing whether the use of a nuclear weapon in space would be regarded as a direct nuclear attack against all NATO member states, whether this would call for a proportional response from the alliance, and what sort of messaging would be required. This would allow the conversation on this capability to be renewed again and to flow from sources outside the United States. Washington should also pursue similar bilateral statements with its close Indo-Pacific allies, particularly Japan, South Korea, and Australia. The European Union, through the goals outlined in its Space Strategy, could also capitalize on further involvement to strengthen capability resilience in space, particularly for European space actors.

BOLSTERING U.S. SPACE DEFENSE INFRASTRUCTURE

In light of the changing threat picture in space, particularly with the addition of a nuclear dimension, the United States may seek to revisit its approach to defense in the realm. As illustrated in the second escalation scenario, the United States has a growing reliance on proliferated satellite constellation architectures for mission assurance and resilience. Despite proliferated architectures providing a certain level of resilience, this approach may be worth reconsidering for other space capabilities.³⁶ Specifically,

32 "NATO's Overarching Space Policy," NATO, June 27, 2019, https://www.nato.int/cps/en/natohq/official_texts_190862.htm.

33 Mikayla Easley, "NATO Looks to Publish First Commercial Space Strategy in 2025," DefenseScoop, October 10, 2024, <https://defensescoop.com/2024/10/10/nato-commercial-space-strategy-2025/>.

34 "EU Space Strategy for Security and Defence," European Commission, 2024, https://defence-industry-space.ec.europa.eu/eu-space/eu-space-strategy-security-and-defence_en.

35 NATO, "The Hague Summit Declaration," press release, June 25, 2025, https://www.nato.int/cps/en/natohq/official_texts_236705.htm.

36 Berkowitz and Williams, *Russia's Space-Based*.

there would need to be a hardening of critical space systems against excess radiation going forward, especially for new capabilities providing ISR functions, missile warning, tracking, and defense, as well as NC3. A separate debate as to whether existing capabilities could be hardened also has its merits. The U.S. Space Force stipulates that while it “performs missile warning, combat power projection, electromagnetic warfare, and nuclear detonation detection, the USSF is not currently seeking commercial support for these missions.”³⁷ This may need to change going forward given the advancements the technological sector continues to make within the space and cyber domains, and the United States may need to consider having more active defenses to suppress and even destroy future threats.³⁸

The first escalation scenario demonstrated the critical nature of NC3 infrastructure, which will need to be secured to respond to the devolving threat environment in space. Both Russia and China have strengthened their counterspace capabilities, reinforcing the need for the United States to advance its NC3 modernization.³⁹ Given that U.S. NC3 is reliant upon space-based equipment, such as communications and early-warning satellites, continued modernization efforts may need to be particularly tailored to meet nuclear surety requirements and prioritized as part of the U.S. program of record for its nuclear defense and security programs. There have been efforts to modernize these space-based components, such as eliminating exploitable cyber and supply chain vulnerabilities and reducing overreliance on a small number of satellites. A balance will need to be found within the Department of Defense between prioritizing NC3 modernization and not rushing to deploy space-based NC3 that is not well integrated, suffers from avoidable supply chain and cybersecurity vulnerabilities, or contains other weaknesses that adversaries and hackers could exploit during the decades in which the next generation of space-based NC3 is likely to operate.⁴⁰

CONCLUSION

The potential for a nuclear war to be fought in space—and that possibility that this could occur in our lifetimes—is undoubtedly horrifying and necessitates continued work to for prevention and mitigation. This analysis has highlighted two key considerations that should be taken into account in order to mitigate any potential impacts from a Russian nuclear-armed ASAT. First, there must be a continued assessment of the West’s overreliance on space-based capabilities that facilitate much of the modern way of life. This includes analyzing which existing space capabilities could be affected or incapacitated during a conflict and undertaking regular military exercises to practice operating in the absence of space-based capabilities. Second, gaining a better understanding of the escalation dynamics resulting from a nuclear-armed ASAT—and what can be done to deter and mitigate the risk of miscalculation—will be equally critical. Both of these elements are critical to developing response options, including through international and diplomatic efforts, and is likewise necessary to identify better international forums for future decisionmaking on issues in space that intersect with the nuclear realm.

37 U.S. Space Force, *U.S. Space Force Commercial Strategy* (Washington, DC: Department of the Air Force, April 8, 2024), https://www.spaceforce.mil/Portals/2/Documents/Space%20Policy/USSF_Commercial_Space_Strategy.pdf.

38 Berkowitz and Williams, *Russia’s Space-Based*.

39 Peter L. Hayes and Sarah Mineiro, “How the US Can Counter Russian and Chinese Nuclear Threats in Space,” Atlantic Council, *New Atlanticist*, October 28, 2024, <https://www.atlanticcouncil.org/blogs/new-atlanticist/how-the-us-can-counter-russian-and-chinese-nuclear-threats-in-space/>.

40 Ibid.

Modernization, Diplomacy, and Strategic Stability Across Asia



Navigating the Depths

India's Naval Modernization and Implications for the Indian Ocean Region

By Hrishita Badu¹

INTRODUCTION

In November 2018, when New Delhi announced that its first domestically built nuclear-powered submarine, the INS *Arihant*, had completed a “deterrence patrol,” Prime Minister Narendra Modi declared it a “fitting response to those who indulge in nuclear blackmail”—implying this completion of India’s nuclear triad would deter its neighbors Pakistan and China.² When India commissioned its second of four planned *Arihant*-class nuclear submarines, the INS *Arighaat*, in August 2024, Pakistan raised concerns of instability in the Indian Ocean Region (IOR).³ Chinese state media also voiced concerns, specifically using Modi’s 2018 language against him.⁴ Amid rising threat perceptions, the IOR is emerging as an arena for rivalry between China, India, and Pakistan as all three pursue sea-based deterrents, a shift from the region’s traditional focus on land-based and aerial delivery systems.

The extension of naval competition to the Indian Ocean introduces new challenges into the already complex security relations among the three countries, with implications for regional stability and the balance of power in the region. Chinese President Xi Jinping has expressed that “the task of building a strong navy has never been as urgent as it is today,” reflecting China’s determination to project

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- 1 Hrishita Badu is a research assistant to Dr. Oriana Skylar Mastro at the Center for International Security and Cooperation (CISAC), Stanford University.
 - 2 “India Says Nuclear Submarine Makes First Patrol; Modi Warns Against ‘Misadventure,’” Reuters, November 6, 2018, <https://www.reuters.com/article/world/india-says-nuclear-submarine-makes-first-patrol-modi-warns-against-misadventure-idUSKCN1NA1H8/>.
 - 3 Malaika Afridi, “Commissioning of INS-Arighat: India’s Growing Undersea Nuclear Capabilities and its Implications on Deterrence Stability in South Asia,” Institute of Strategic Studies Islamabad, September 16, 2024, https://issi.org.pk/wp-content/uploads/2024/09/IB_Malaika_Sep_16_2024.pdf.
 - 4 Liu Xuanzun, “India’s Second Nuclear Missile Submarine Should Be Used Responsibly: Experts,” *Global Times*, August 29, 2024, <https://www.globaltimes.cn/page/202408/1318865.shtml>.

power at sea.⁵ India, for its part, is shifting its maritime efforts in the region from a purely economic focus to a more military and geostrategic perspective.

India launched the INS *Arihant* in 2016 and commissioned the INS *Arighaat* in 2024, which can carry K-15 and K-4 submarine-launched ballistic missiles (SLBMs), the latter capable of reaching Islamabad and Beijing.⁶ Pakistan, concerned over India's deterrence strategy, has countered by deploying nuclear-capable submarine-launched cruise missiles (SLCMs) and pursuing *Hangor*-class submarines, jointly built with China, to ensure its sea-based retaliatory capabilities.⁷ Meanwhile, Chinese maritime interests have driven infrastructure projects along key routes to Shanghai and Hong Kong and strengthened ties with six Indian Ocean islands.⁸

This paper analyzes the burgeoning naval competition in South Asia by focusing on India's naval modernization and how this is transforming its role in the IOR and the broader Indo-Pacific. It also examines the extent to which this buildup of aircraft carriers, nuclear submarines, indigenous shipbuilding, and naval infrastructure strengthens India's strategic posture and deterrence capability. What are the regional implications of this naval modernization when it interacts with China's own global ambitions, Pakistan's asymmetric strategy, and India's own efforts at deterrence, external partnerships, and maritime diplomacy policy?

This paper first discusses the brief evolution of India's naval doctrine and the importance of the IOR. It then examines the key components of the country's naval modernization, comparing its current capabilities with those of China and Pakistan to assess the relative balance of power in the region and numerically contextualize the modernization efforts. Finally, the paper discusses implications of India's naval modernization for the IOR and concludes with key findings.

INDIA'S NAVAL DOCTRINE AND IMPORTANCE OF THE INDIAN OCEAN REGION

The naval modernization drive that India has undertaken is ambitious. It is transforming its navy not only with new platforms, advanced weapons, and indigenous shipbuilding, but also with the addition of a new aircraft carrier, submarines, and stealth frigates.⁹ Having long recognized that the country's security and destiny are linked to the seas, India nevertheless lacked a unified naval doctrine until the 1998 Maritime Military Strategy, instead relying on a territorial outlook focused on coastal defense and opposing extra-regional powers.¹⁰ This strategy laid the groundwork for the country's

5 "Xi Jinping Urges Building of Strong Chinese Navy," CGTN, April 12, 2018, <https://news.cgtn.com/news/3367444d-346b7a6333566d54/index.html>.

6 "India Submarine Capabilities," Nuclear Threat Initiative, March 25, 2025, <https://www.nti.org/analysis/articles/india-submarine-capabilities/>.

7 Pradip R. Sagar, "Navy Day Reminder: A Buffed up Pakistan Naval Force in India's Backyard," *India Today*, December 2, 2024, <https://www.indiatoday.in/india-today-insight/story/navy-day-reminder-a-buffed-up-pakistan-naval-force-in-indias-backyard-2643655-2024-12-02>.

8 China Power Team, "How Is China Influencing Global Maritime Connectivity?," *ChinaPower*, CSIS, April 30, 2021, <https://chinapower.csis.org/china-ports-connectivity/>; and Swaran Singh, "China's Inroads into India's Neighbouring Island Nations: Initiatives and Implications," *Journal of Indian Ocean Studies* 32, no. 2 (May–August 2024): 1–15, <https://www.jnu.ac.in/Faculty/ssingh/China%E2%80%99s%20Inroads%20into%20India%E2%80%99s%20Neighbouring%20Island%20Nations:%20Initiatives%20and%20Implications.pdf>.

9 "India Boosts Naval Fleet as China's Presence in Indian Ocean Grows," *Indian Defence News*, March 14, 2025, <https://www.indiandefensenews.in/2025/03/india-boosts-naval-fleet-as-chinas.html>.

10 Baljit Singh Mann, "Changing Dynamics of India's Indian Ocean Policy," *Maritime Affairs: Journal of the National Maritime Foundation of India* 13, no. 2 (Winter 2017): 11–22, <https://doi.org/10.1080/09733159.2017.1410937>.

first maritime doctrine in 2004, which highlighted the importance of leveraging the IOR for India's national interests rather than dominating it.¹¹

The Indian Ocean, the world's third largest ocean, is a vital trade hub with key chokepoints, such as the Hormuz, Bab el-Mandeb, and Malacca Straits, through which most global energy trade flows, including to major Asian economies such as China, India, and Japan. For example, around 20 million barrels of oil pass through the Strait of Hormuz per day, accounting for roughly 20 percent of global oil trade, making strait security a matter of international concern.¹² The IOR has also become a theater for military competition. The United States and United Kingdom maintain a major joint base at Diego Garcia in the Chagos Islands, while France has a permanent presence in La Réunion and Mayotte.¹³ China's presence has also grown, with regular People's Liberation Army Navy (PLAN) patrols in the region, a base in Djibouti since 2017, and investments in ports such as Gwadar in Pakistan and Hambantota in Sri Lanka. While China officially emphasizes the commercial importance of these ports, analysts note that they also provide contingency options against possible future obstruction by adversarial states such as India, Japan, or the United States. This fits into what is often described as a Mahanian "string of pearls" strategy to safeguard China's sea lanes and extend its influence across the IOR, which has raised concerns in New Delhi.¹⁴

For India, the IOR's significance is immense: Over 95 percent of its trade by volume and 68 percent by value moves through these waters. Given that India has 7,500 km of coastline and more than 200 ports, the Indian Ocean supports its commerce, energy, and fishing industries.¹⁵ The country's 2007 maritime doctrine reaffirmed the importance of controlling sea lines of communication (SLOCs), initiated procurement of new carriers such as the INS *Vikramaditya* and INS *Vikrant*, led to overhauls in coastal security in the wake of the 2008 Mumbai attacks, and helped the Navy maintain continuous antipiracy patrols in the Gulf of Aden.¹⁶

India's naval doctrine has since grown more assertive and outward-looking.¹⁷ Its 2015 maritime doctrine elevated far-flung areas such as the Red Sea, Gulf of Aden, and Gulf of Oman to "primary" areas of interest, and "secondary" interests were broadened to include some littoral regions of Southeast Asia and the Western Pacific.¹⁸ More importantly, the accompanying update to the

11 Allah Nawaz, "India's Evolving Maritime Strategy," *South Asian Voices*, Stimson Center, May 31, 2023, <https://southasianvoices.org/indias-evolving-maritime-strategy/>.

12 "Amid Regional Conflict, the Strait of Hormuz Remains Critical Oil Chokepoint," U.S. Energy Information Administration, June 16, 2025, <https://www.eia.gov/todayinenergy/detail.php?id=65504>.

13 Léonie Allard, "Deciphering French Strategy in the Indo-Pacific," *War on the Rocks*, March 13, 2025, <https://warontherocks.com/2025/03/deciphering-french-strategy-in-the-indo-pacific/>.

14 David Brewster, "Silk Roads and Strings of Pearls: The Strategic Geography of China's New Pathways in the Indian Ocean," *Geopolitics* 22, no. 2 (2017): 269–91, <https://doi.org/10.1080/14650045.2016.1223631>.

15 "95% of India's Trade Volume, 68% by Value Move via Coastal Routes: Govt Official," *BW Business World*, January 23, 2025, <https://www.businessworld.in/article/95-of-indias-trade-volume-68-by-value-move-via-coastal-routes-govt-official-545734>.

16 India's carrier capability, however, dates back decades: The first INS *Vikrant*, acquired from the United Kingdom and commissioned in 1961, was a source of national pride and played a decisive role in the 1971 war with Pakistan before its decommissioning in 1997, while the INS *Viraat*, also purchased from the United Kingdom and commissioned in 1987, served as the navy's flagship for nearly three decades until it was retired in 2017. See Brad Lendon, Vedika Sud, Esha Mitra, and Swati Gupta, "India's First Homegrown Aircraft Carrier Puts It among World's Naval Elites," *CNN*, September 2, 2022, <https://www.cnn.com/2022/09/02/asia/india-indigenous-aircraft-carrier-vikrant-commissioned-intl-hnk-ml>; and "Coastal Security," Indian Coast Guard, updated August 22, 2024, <https://www.indiancoastguard.gov.in/coastal-security>.

17 Probal Ghosh, "Indian Ocean Dynamics: An Indian Perspective," *East Asia Forum*, April 5, 2011, <https://eastasiaforum.org/2011/04/05/indian-ocean-dynamics-an-indian-perspective/>.

18 Indian Ministry of Defence (Navy), *Indian Maritime Doctrine 2009* (Standard Press, 2009), 68, archived at https://web.archive.org/web/20220201112512/https://inexartificers.com/public/uploads/ebooks/Ebook_1_07-01-2019_11_36_53.pdf.

Maritime Security Strategy articulated the navy's role as a "net security provider," a phrase that had been politically used for years but now found definition in an official document: "the state of actual security available in an area, upon balancing prevailing threats, inherent risks and rising challenges in a maritime environment, against the ability to monitor, contain and counter all of these."¹⁹ The Maritime Security Strategy envisions the Indian navy as the main instrument for regional stability, tying into Modi's Security and Growth for All in the Region (SAGAR) vision, in which India aims to foster a secure and inclusive IOR.²⁰ The strategy emphasizes cooperative security and collective action against threats such as piracy, terrorism, and natural disasters while supporting smaller littoral states.²¹ For example, in 2021 India extended a \$100 million line of credit to Mauritius for defense needs and a \$50 million agreement to the Maldives to strengthen its coast guard and maritime infrastructure.²²

KEY COMPONENTS OF INDIA'S NAVAL MODERNIZATION EFFORT

India's Maritime Security Strategy and SAGAR doctrine can be divided into five main objectives: (1) safeguard SLOCs and energy flows; (2) exercise sea control and sea denial in the IOR; (3) field a survivable, credible sea-based nuclear deterrent; (4) build maritime domain awareness capacity with partners; and (5) provide regional public goods, especially humanitarian assistance and disaster relief (HADR), in its role as a "net security provider." The navy operationalizes these aims through mission-based deployments at key chokepoints, and SAGAR frames first-responder roles.²³ The following sections outline the main components of India's naval modernization, the strategic goals they intend to advance, and assessments of how well developments align with stated objectives.

AIRCRAFT CARRIERS

Despite aircraft carriers' high costs and vulnerabilities, the Indian navy continues to view them as central to its maritime strategy. It currently operates two: the 44,500-ton INS *Vikramaditya*, acquired from Russia in 2013, and the 40,000-ton INS *Vikrant*, commissioned in 2022 as India's first indigenously built carrier, demonstrating major domestic shipbuilding progress.²⁴ These allow India to field two battle groups for sea control. A third carrier, the INS *Vishal*, would have a capacity of around 65,000 tons, making it able to launch heavier aircraft for surveillance and more advanced fighter jets. However, this project is still at a conceptual stage, and its construction is anticipated to take around 28–33 years since its announcement in 2011.²⁵ To strengthen carrier-based aviation in the meantime, India signed a \$7.4 billion deal with France in April 2025 for 26 Rafale-M fighter jets, with deliveries expected by 2030.²⁶

19 Indian Ministry of Defence (Navy), *Ensuring Secure Seas: Indian Maritime Security Strategy* (New Delhi: Indian Ministry of Defence, 2015), 80, 158, https://bharatshakti.in/wp-content/uploads/2016/01/Indian_Maritime_Security_Strategy_Document_25Jan16.pdf.

20 *Ibid.*, 23.

21 Yash Kumar, "Security and Growth for All in the Region, (SAGAR) 2015," Impact and Policy Research Institute, May 16, 2025, <https://www.impriindia.com/insights/security-growth-for-all-regions-sagar/>.

22 Darshana M. Baruah, Nitya Labh, and Jessica Greely, "Mapping the Indian Ocean Region," Carnegie Endowment for International Peace, June 15, 2023, <https://carnegieendowment.org/research/2023/06/mapping-the-indian-ocean-region?lang=en>.

23 Indian Ministry of Defence (Navy), *Ensuring Secure Seas*.

24 Abhijit Singh, "INS Vikrant Sets Sail: Why It Is Key to India's Maritime Strategy," *Indian Express*, September 3, 2022, <https://indianexpress.com/article/opinion/columns/ins-vikrant-india-maritime-strategy-8127379/>.

25 Shubhangi Palve, "India to Counter China's Fujian with 3rd Aircraft Carrier; Defense Minister Says 'Work On' for Third Carrier," *EurAsian Times*, May 16, 2024, <https://www.eurasiantimes.com/india-to-counter-chinas-fujian-with-3rd-aircraft/>.

26 Shivam Patel and Surbhi Misra, "India Signs \$7.4 Billion Deal to Buy 26 Rafale Fighter Jets," Reuters, April 28, 2025, <https://www.reuters.com/world/india/india-signs-74-billion-deal-with-france-buy-26-rafale-fighter-jets-2025-04-28>.

Aircraft carriers directly serve India's doctrinal objective of securing SLOCs and asserting control in primary areas such as the Arabian Sea and Bay of Bengal. These mobile, survivable alternatives to land bases provide air cover, convoy defense, and fleet air defense while also signaling presence and deterrence through exercises. Additionally, the *Vikrant's* indigenous construction advances the goal of self-reliance. Notably, Indian carriers have participated in multinational drills, such as the annual Maritime Exercise Malabar with the Quadrilateral Security Dialogue (Quad)—consisting of India, the United States, Japan, and Australia—and the Varuna 2025 exercises between France's *Charles de Gaulle* and India's *Vikrant*.²⁷ These drills illustrate India's potential role in warfighting while building maritime awareness and interoperability with partners, both key to India's goal of becoming a "net security provider" under SAGAR.

However, there are gaps in terms of availability and aerial strength. With only two carriers, and one typically undergoing upgrades or repairs, India cannot sustain continuous availability. Its fleet of Russian MiG-29K fighter jets is also aging, and the Rafale-M deliveries will take time. For carriers to fulfill their intended role against advanced adversaries, India will also need to strengthen anti-submarine warfare capabilities, modernize naval escorts, and expand logistics infrastructure to ensure survivability in contested environments.

NUCLEAR AND CONVENTIONAL SUBMARINES

India's naval modernization has given utmost importance to its nuclear submarine fleet, which could serve as a powerful deterrent and give it a sustained underwater presence. The INS *Arihant* was commissioned in August 2016, becoming India's first nuclear-powered ballistic missile submarine (SSBN) and completing the sea leg of the country's nuclear triad. It can carry up to 12 K-15 SLBMs, which have a range of around 750 km, as well as the indigenously produced, nuclear-capable Nirbhay cruise missiles.²⁸

A second SSBN, the *Arihant*-class INS *Arighaat*, was launched in 2017 and commissioned in August 2024.²⁹ Two larger SSBNs (designated S4 and S4* in Indian reports) with heavier payloads are undergoing testing; the S4, to be named the INS *Aridhaman*, is expected to enter service later in 2025 after nearly three years of trials, while the S4* is still being tested a year after being launched.³⁰ These SSBNs are reportedly larger than both the *Arihant* and *Arighaat* and will likely carry more nuclear-tipped ballistic missiles.³¹ There have also been reports that the Indian government has approved the next generation of S5-class SSBNs, projected to have a capacity of over 13,000 tons.³²

27 Australian Ministry of Defense, "Exercise Malabar Deepens Regional Military Cooperation," press release, August 23, 2023, <https://www.defence.gov.au/news-events/releases/2023-08-23/exercise-malabar-deepens-regional-military-cooperation>; and Aaron-Matthew Lariosa, "French, Indian Navies Begin Dual Carrier Strike Group Drills," USNI News, March 19, 2025, <https://news.usni.org/2025/03/19/french-indian-navies-begin-dual-carrier-strike-group-drills>.

28 "India Submarine Capabilities," Nuclear Threat Initiative.

29 Indian Ministry of Defense, "Second Arihant-Class Submarine 'INS Arighaat' Commissioned into Indian Navy in the Presence of Raksha Mantri in Visakhapatnam," press release, August 29, 2024, <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2049870>.

30 "India Expands Its Sea-Based Nuclear Deterrence with Commissioning of INS Aridhaman Submarine," *Global Defense News*, February 4, 2025, <https://armyrecognition.com/news/navy-news/2025/india-expands-its-sea-based-nuclear-deterrence-with-commissioning-of-ins-aridhaman-submarine>; and Dinakar Peri, "India's Fourth Nuclear Submarine Launched into Water," *The Hindu*, October 23, 2024, <https://www.thehindu.com/news/national/indias-fourth-nuclear-submarine-launched-into-water/article68783731.ece>.

31 Junaid Kathju, "India's New Submarine Base Targets China's Growing Sea Power," *South China Morning Post*, April 13, 2025, <https://www.scmp.com/week-asia/politics/article/3306217/indias-new-submarine-base-targets-chinas-growing-sea-power>.

32 Raunak Kunde, "India's Upcoming S5-Class SSBN to See Increase in SLBMs Tubes," Indian Defence Research Wing, December 28, 2024, <https://idrw.org/indias-upcoming-s5-class-ssbn-to-see-increase-slbms-tubes/>.

India has also approved the indigenous construction of two new nuclear attack submarines (SSNs) in 2024, at an estimated cost of \$5.4 billion.³³ India has relied on the Russian-made INS *Chakra*, first leased in the late 1980s and more recently from 2012 to 2021; it leased the INS *Chakra III* in 2019, which is expected to join active service by 2028.³⁴ In the longer term, India plans to build a fleet of six SSNs under Project 77, which will eventually produce additional indigenous vessels with long-range strike and carrier escort capability, but in the meantime the country faces a gap through most of the 2020s with no active SSN.³⁵

However, India's nuclear submarine ambitions cannot be separated from its existing diesel-electric attack submarine (SSK) fleet, which remains the operational foundation of its undersea warfare capability. The Indian navy fields 17 conventional submarines: seven Russian *Kilo*-class submarines, four German-designed Howaldtswerke-Deutsche Werft (HDW) Type-209s, and six French-designed *Scorpène*-class submarines.³⁶ The latest of these is the INS *Vagsheer*, commissioned on January 15, 2025.³⁷ These SSKs perform the bulk of India's patrol, anti-surface, and anti-submarine operations and are critical in screening and protecting SSBN "bastions" in the Bay of Bengal.³⁸ Despite undergoing life-extension refits and upgrades, many are nearing retirement and lack the capability of newer vessels. For instance, none of India's current conventional submarines have air-independent propulsion (AIP), a technology that would allow them to stay underwater for over two weeks.³⁹

Submarines serve India's goal of maintaining a credible sea-based nuclear deterrent, with SSBNs intended to provide survivable second-strike capability. While the *Arihant's* highly publicized 2018 patrol was a significant milestone—with some experts arguing that this, along with two the SSBNs under construction, signaled intent toward continuous at-sea deterrence (CASD)—India will likely still follow bastion strategy and patrol closer to home.⁴⁰ CASD maximizes survivability signaling but requires at least four or more SSBNs to ensure at least one submarine is on deterrence patrol at all times, ideally farther away from territorial waters. India's naval infrastructure, such as Project Varsha (discussed below) and the ongoing expansion of the Karwar naval facility, also reinforces its bastion-focused approach.⁴¹

The absence of operational AIP on India's own vessels further weakens stealth. Both Pakistan and China operate AIP-equipped submarines, but India's 17 SSKs must surface more frequently to charge

33 "India Prepares to Build Two Nuclear-Powered Attack Submarines," Reuters, October 10, 2024, <https://www.reuters.com/world/india/india-prepares-build-two-nuclear-powered-attack-submarines-2024-10-10/>.

34 "Russia Offers Second Akula-Class Nuclear Submarine to India: Report," Indian Defence Research Wing, July 2, 2025, <https://idrw.org/russia-offers-second-akula-class-nuclear-submarine-to-india-report/>.

35 Parthu Potluri, "Project-77: An Analysis of the Indian Navy's Nuclear Attack Submarine Program," *Strategic Frontier*, November 26, 2024, <https://www.strategicfront.org/project-77-an-analysis-of-the-indian-navys-nuclear-attack-submarine-program/>.

36 "India Submarine Capabilities," Nuclear Threat Initiative.

37 Naval Group, "Commissioning of Ins Vagsheer, the Sixth Kalvari-Class Submarine Entirely Made in India Based on Scorpene® Design," press release, January 16, 2025, <https://www.naval-group.com/en/commissioning-ins-vaghsheer-sixth-kalvari-class-submarine-entirely-made-india-based-scorpener>.

38 Sidharth Raimedhi, "India Is Turning Bay of Bengal into SSBN Bastion. China Can Overreact," *The Print*, September 4, 2024, <https://theprint.in/opinion/india-is-turning-bay-of-bengal-into-ssbn-bastion-china-can-overreact/2251196/>.

39 Shivam Patel, "German-Indian JV Emerges as Sole Contender for \$5 Billion India Submarine Deal," Reuters, January 23, 2025, <https://www.reuters.com/markets/deals/german-indian-jv-emerges-sole-contender-5-billion-india-submarine-deal-2025-01-23/>.

40 Tim Fish, "First Nuclear Deterrence Patrol Marks Major Step in Indian Submarine Force," USNI News, November 12, 2018, <https://news.usni.org/2018/11/12/first-nuclear-deterrence-patrol-marks-major-step-indian-submarine-force>; and Yogesh Joshi, "Angles and Dangles: Arihant and the Dilemma of India's Undersea Nuclear Weapons," *War on the Rocks*, January 14, 2019, <https://warontherocks.com/2019/01/angles-and-dangles-arihant-and-the-dilemma-of-indias-undersea-nuclear-weapons/>.

41 Hely Desai, *Silent Deterrents: India's Undersea Gamble Amid China's Indo-Pacific Surge* (New Delhi: Centre for Strategic and Defense Research, 2025), 2, https://csdronline.com/wp-content/uploads/2025/06/CSDR_June25_Silent-Deterrents-3.pdf.

batteries. Although India is retrofitting an indigenous AIP module on *Kalvari*-class vessels, the program has faced delays, and full operational capability is unlikely to be realized before the 2030s.⁴²

ANTISHIP MISSILES

Modern missiles and precision weapons are central to India's sea-denial strategy. In particular, the BrahMos supersonic cruise missile, jointly developed with Russia, is the navy's "prime strike weapon" deployed on frontline combat platforms.⁴³ With a range of over 350 km in recent tests and a Mach 2.8 sea-skimming speed, it can equip *Kolkata*-class and *Visakhapatnam*-class destroyers (carrying 16 BrahMos missiles each).⁴⁴ The latest *Talwar*-class frigates are also being armed with the BrahMos system instead of older Klub missiles.⁴⁵

India is expanding its strike portfolio beyond BrahMos, including submarine-launched variants planned under the P-75I program.⁴⁶ Meanwhile, India's Defense Research and Development Organization (DRDO) and navy successfully tested the indigenously developed Naval Anti-Ship Missile–Short Range (NASM-SR) on February 25, 2025, and the BrahMos-II hypersonic missile, with an anticipated range of 1,500 km, is under development.⁴⁷ To increase submarine firepower, India has also acquired Russia's Kalibr/Klub missiles for its *Kilo*-class fleet and operates U.S.-supplied Harpoon Block II missiles on P-8I aircraft.⁴⁸

Strategically, India's missile modernization clearly supports its doctrine of sea denial. The BrahMos and its follow-on variants raise the cost of PLAN and Pakistan navy operations near chokepoints and coasts. Their integration with destroyers and frigates also aligns with the 2015 emphasis on precision strike capability. The NASM-MR currently under development is tailored for coastal defense, anti-access/area denial (A2/AD) operations, preemptive strikes against hostile naval forces, and flexibility in short-range engagements.⁴⁹ The planned BrahMos-II will also give India hypersonic strike capability against advanced defenses. However, it is important that India ensure new strike systems are effectively integrated with anti-submarine warfare and surveillance platforms to maintain survivability.

42 "DRDO's Eight-Year Delay Hits Indian Submarines While Pakistan Gains Lead Underwater," *Economic Times*, August 4, 2025, <https://economictimes.indiatimes.com/news/defence/drdo-eight-year-delay-hits-indian-submarines-while-pakistan-gains-lead-underwater/articleshows/123090548.cms?from=mdr>.

43 "Ship-Based Weapon Complex System," BrahMos Aerospace, archived January 23, 2025, <https://web.archive.org/web/20250123213834/https://brahmos.com/content.php?id=15>.

44 BrahMos Aerospace, "India test-fires advanced version of BRAHMOS missile," press release, January 11, 2022, <https://www.brahmos.com/brahmos-in-media/100>; and "Are Indian Navy's Ships Under Armed?," *Battle Machines*, October 8, 2023, <https://battlemachines.org/2023/10/08/are-indian-navys-ships-under-armed/>.

45 Sushil Ramsay, "Indian Navy's Acquisition and Modernisation Plans," *SP's Naval Forces* 13, no. 2 (April/May 2018): 1–5, <https://www.spsnavalforces.com/story/?id=509>.

46 Raunak Kunde, "BrahMos Missile to Enhance P-75I Submarines with Vertical Launch Capability for Long-Range Strikes," *Indian Defence Research Wing*, July 04, 2025, <https://idrw.org/brahmos-missile-to-enhance-p-75i-submarines-with-vertical-launch-capability-for-long-range-strikes/>.

47 Indian Ministry of Defense, "DRDO & Indian Navy Successfully Conduct Flight-Trials of First-of-its-Kind Naval Anti-Ship Missile," press release, February 26, 2025, <https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2106482>; and P.C. Katoch, "BrahMos-II and Indigenous Star Missile," *SP's Land Forces*, May 27, 2025, <https://www.spslandforces.com/experts-speak/?id=1274&h=BrahMos-II-and-Indigenous-Star-Missile>.

48 Raghav Patel, "India Navy Acquires Kalibr-PL Anti-Ship Cruise Missiles to Equip Kilo-Class Submarine Fleet, Increasing Deterrent in IOR," *Defence.in*, February 23, 2025, <https://defence.in/threads/india-navy-acquires-kalibr-pl-anti-ship-cruise-missiles-to-equip-kilo-class-submarine-fleet-increasing-deterrent-in-ior.13011/>; and Greg Waldron, "US Government Clears Harpoon, Torpedo Deal for India P-8Is," *FlightGlobal*, April 13, 2020, <https://www.flightglobal.com/fix-wing/us-government-clears-harpoon-torpedo-deal-for-india-p-8is/137863.article>.

49 Raunak Kunde, "Indian Navy Bolsters Lo-Hi Anti-Ship Capabilities to Counter Chinese Naval Power," *Indian Defence Research Wing*, March 16, 2025, <https://idrw.org/indian-navy-bolsters-lo-hi-anti-ship-capabilities-to-counter-chinese-naval-power/>.

NAVAL INFRASTRUCTURE AND BASES

In order to fully modernize its naval capabilities, focusing on hardware alone is not enough. India is also heavily investing in naval infrastructure by expanding bases, shipyards, and support facilities to accommodate its growing fleet and strengthen operational reach. Two infrastructure projects are central: Project Varsha (Rambilli Base) on the east coast and Project Seabird (Karwar Base) on the west coast.

Expected to open in 2026, Rambilli Base, near the Eastern Naval Command headquarters at Visakhapatnam in Andhra Pradesh, is being designed with underground tunnels and pens to house the *Arihant*-class SSBNs and future SSNs.⁵⁰ This project will provide protection and support for continuous submarine operations and facilities for India's nuclear fleet, reflecting its bastion strategy in the Bay of Bengal and mirroring China's own expansion of nuclear submarine facilities.⁵¹

Project Seabird at Karwar in Karnataka is India's flagship western base expansion. Phase I finished in 2011, and the ongoing Phase IIA adds two major piers, seven residential towers with 320 homes and 149 single-officer units, and extensive new infrastructure, including a 75-meter covered dry berth, technical utilities, and a forthcoming dual-use naval air station to expand capacity for 32 ships and submarines.⁵² Once complete, Karwar will host up to 50 frontline warships and submarines, a new 6,000-foot runway, and both of India's carrier battle groups.⁵³ Strategically located on the Arabian Sea, Karwar reduces dependence on current western Indian naval facilities in Mumbai and provides direct access to sea lanes, strengthening India's ability to surge forces into the Indian Ocean.

Naval infrastructures are important back-end support for India's maritime strategy of credible deterrence, sea control, and sea denial. Project Varsha supports survivable SSBN operations, while Karwar will allow carrier and surface fleet deployment into primary theaters. Together, they extend India's operational reach and also reinforce its "net security provider" role under SAGAR by supporting carrier and submarine deployments as well as humanitarian relief across the Indian Ocean.⁵⁴

MODERNIZATION IN NUMBERS: CHINA VERSUS INDIA VERSUS PAKISTAN

India's incremental but not transformative modernization can be better understood in the context of regional naval modernization, as seen in a comparison of fleet compositions across China, India, and Pakistan (Table 1).

50 Rajat Pandit, "India Plans to Set up Nuclear Submarine Base in Andhra Pradesh Next Year," *Times of India*, April 7, 2025, <https://timesofindia.indiatimes.com/india/india-plans-to-set-up-nuclear-submarine-base-in-andhra-pradesh-next-year/articleshow/120046893.cms>.

51 Tamanna Singh, "INS Varsha: India's Response against China's Maritime Expansion," *ET Edge Insights*, April 9, 2025, <https://etedge-insights.com/featured-insights/geopolitics-and-strategy/ins-varsha-indias-response-against-chinas-maritime-expansion/>.

52 Indian Ministry of Defence, "Hon'ble Raksha Mantri to Inaugurate the Infrastructure/Facilities of Project Seabird," press release, March 4, 2024, <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2011240>.

53 Vishal Thapar, "Indian Navy gives a glimpse of the Eastern Hemisphere's largest naval base-in-the-making," *BWDefence*, May 28, 2022, <https://bwdefence.com/article/indian-navy-gives-a-glimpse-of-the-eastern-hemisphere-s-largest-naval-base-in-the-making-430535>.

54 Indian Ministry of Defence, "Raksha Mantri Shri Rajnath Singh Reviews Development Works at Karwar Naval Base Under 'Project Seabird'," press release, June 24, 2021, <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1730082>.

Table 1: Selected Numbers of Chinese, Indian, and Pakistani Navy Battle Force Ships

	Ship Type	2000	2010	2020	2025	Absolute Change
China	SSBN	1	3	4	6	+5
	SSN	5	6	6	6	+1
	SSK	57	54	48	46	-11
	Aircraft carriers	0	0	1	2	+2
	Destroyers	20	28	28	42	+22
	Total	83	91	87	102	+19
India	SSBN	0	0	1	2	+2
	SSN	0	1	1	0	0
	SSK	16	16	15	17	+1
	Aircraft carriers	1	1	1	2	+1
	Destroyers	8	8	13	12	+4
	Total	25	26	31	33	+8
Pakistan	SSBN	0	0	0	0	0
	SSN	0	0	0	0	0
	SSK	7	5	5	5	-2
	Aircraft carriers	0	0	0	0	0
	Destroyers	0	0	0	0	0
	Total	7	5	5	5	-2

Source: Data from International Institute for Strategic Studies (IISS), “Military Balance+” (database), <https://www.iiss.org/the-military-balance-plus/>. Totals differ from some open-source datasets because the IISS uses a standardized classification system. The total submarine count in the IISS source also includes additional categories not shown here for consistency and comparability across fleets.

Several key observations emerge based on the table:

- India’s fleet grew by a modest 8 vessels from 2000 to 2025, compared to China’s 19. However, in proportional terms, India’s fleet expansion represents a larger percentage increase, reflecting a more significant transformation in capability rather than scale. Both countries have prioritized SSBNs and advanced destroyers, but India’s modernization has been more selective, focused on developing strategic assets such as nuclear submarines, aircraft carriers, and BrahMos-equipped surface ships. This matches India’s doctrine of being a “net security provider” in the IOR by prioritizing specific capabilities that strengthen deterrence and presence over parity with the PLAN.
- Although diesel submarines are foundational to any fleet, India’s number of SSKs stagnated. While Pakistan’s fleet declined by two, the country is modernizing with Chinese-built, AIP-equipped boats. The SSBN bastion strategy further requires quiet SSKs, but India’s fleet is old, noisy, and lacks the AIP technology that would offer stealth and endurance.
- Nuclear submarines are symbolically powerful but still few. As of 2025, India has two SSBNs and no operational SSNs (pending the leased *Chakra III*), compared to China’s six SSBNs and six SSNs. While India’s arsenal is enough to signal a sea-based deterrent, it is not sufficient for CASD and further bastion posture.

- The number of India's carriers and destroyers expanded, but modestly, while China's surged by 24. The INS *Vikrant* symbolizes indigenous progress, but India cannot match the PLAN's expansion. Hence, its strategy cannot be that of parity but rather to embed modernization in naval exercises with other like-minded partners such as the Quad to ensure sea denial and regional primacy.
- Pakistan is pursuing an asymmetric escalation strategy. Although IISS totals show no expansion beyond five submarines, the country is investing in *Hangor*-class SSKs, Type-054 A/P frigates, and nuclear-capable SLCMs, focusing on smaller, modern, often Chinese-supplied and AIP-enabled platforms that complicate India's larger but slower-to-modernize fleet.⁵⁵
- In terms of regional balance, the PLAN's numerical superiority reflects a shift to blue-water power projection, with the Indian Ocean a secondary but expanding theater for China.⁵⁶ India cannot match China's scale nor ignore Pakistan's tactical upgrades. Instead of global projection, its ongoing modernization efforts therefore reflect its focus on regional safeguards, soft power, sea denial, asserting leadership, and building maritime awareness with partners.

IMPLICATIONS FOR REGIONAL SECURITY

The consequences of India's ongoing naval modernization extend beyond its immediate interests and interact with China's global ambitions, Pakistan's asymmetric strategy, and India's own efforts to strengthen deterrence, external coalitions, and maritime diplomacy.

REGIONAL CONSEQUENCES OF CHINA'S GLOBAL AMBITION

Officially, Chinese commentators often downplay New Delhi's naval developments, emphasizing instead that "the Indian Ocean is not India's ocean" and insisting on all countries' right to free navigation.⁵⁷ Strategically, China has doubled down on expanding its naval capabilities and presence across the IOR, conducting exercises from the Gulf of Oman to the Strait of Malacca and deepening ties with key players in the region.⁵⁸ However, this buildup is not driven by India but overwhelmingly by Beijing's ambitions and its competition with the United States. Among other things, China's naval buildup reflects concerns over Taiwan, the South China Sea, U.S. competition, and protecting Chinese SLOCs.⁵⁹ It has modernized the PLAN at a record pace specifically to protect its global maritime interests and is now the largest navy in the world—estimated to grow from its 370 current vessels to 435 by the end of the decade.⁶⁰

China's carrier program is a major part of this ambition. The commissioning of the *Liaoning* in 2012 and the building of two indigenous carriers—the *Shandong*, commissioned in 2019, and the *Fujian*, launched in 2022—are all great power symbols that China modeled after the United

55 Sagar, "Navy Day Reminder"; and Shervin Taheran, "Pakistan Advances Sea Leg of Triad," *Arms Control Today* 48, no. 5 (June 2018), <https://www.armscontrol.org/act/2018-06/news-briefs/pakistan-advances-sea-leg-triad>.

56 Darshana M. Baruah, "China in the Indian Ocean: A Stronger Indo-Pacific Presence," IISS, May 22, 2025, <https://www.iiss.org/online-analysis/charting-china/2025/05/china-in-the-indian-ocean-a-stronger-indo-pacific-presence/>.

57 Prashant Hosur Suhas and Christopher K. Colley, "It's Still the Indian Ocean: Parsing Sino-Indian Naval Competition Where It Counts," *War on the Rocks*, May 7, 2024, <https://warontherocks.com/2024/05/its-still-the-indian-ocean-parsing-sino-indian-naval-competition-where-it-counts/>; and Peter Martin et al., "China Piles the Pressure on India in Its Own Backyard," *Bloomberg*, March 11, 2025, <https://www.bloomberg.com/graphics/2025-indian-ocean-china-india/>.

58 Amira El-Fekki, "China's Military Presence Grows on Doorstep of New U.S. Partner," *Newsweek*, May 28, 2025, <https://www.newsweek.com/china-military-indian-ocean-us-india-strategic-partnership-2077975>.

59 Ronald O'Rourke, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, CRS Report No. RL33153 (Washington, DC: Congressional Research Service updated April 2025), 3–4, https://www.congress.gov/crs_external_products/RL/PDF/RL33153/RL33153.284.pdf.

60 Suhas and Colley, "It's Still the Indian Ocean."

States to compete with it.⁶¹ The *Fujian*, for instance, “is equipped with an electromagnetic catapult launch system like the US Navy’s new Ford-class carriers,” designed primarily for blue-water power projection.⁶² In addition, the U.S. Department of Defense’s 2024 report on China notes the growing replenishment fleet, including new *Fuyu*-class combat-support ships, which enable longer deployments.⁶³ The eight Type 071 amphibious transport docks—vessels capable of carrying troops, helicopters, and armored vehicles—further indicate a shift toward expeditionary capability consistent with the strategic doctrine of “near seas defense and far seas protection,” which envisions regular operations beyond China’s immediate coastline.⁶⁴

Nevertheless, these developments have significant implications for India. The modernization of the PLAN and diversification of its deployments into the IOR means there will be competition in the region. Since China’s maritime security interests increasingly overlap with India’s, naval interactions have intensified, not because Beijing fears New Delhi but because its global ambitions bring it into India’s strategic backyard.⁶⁵ As Chinese activities expand into the Bay of Bengal, New Delhi can respond by strengthening assets such as the Andaman and Nicobar Command, which provides critical surveillance and monitoring services.⁶⁶ The goal is not to match Chinese numbers but to complicate PLAN operations near India’s coasts while maintaining competitive advantage, deterring adversaries, and strengthening partnerships.

PAKISTAN’S ASYMMETRIC UNDERSEA STRATEGY

Pakistan views India’s naval modernization with concern, welcoming outside partnership when possible and adopting an asymmetric strategy, defined as one that aims “to deter conventional attacks by enabling a state to respond with rapid, asymmetric escalation to first use of nuclear weapons.”⁶⁷

First, Pakistan’s three French-built, AIP-enabled Agosta-90B SSKs provide extended underwater endurance and stealth; armed with heavyweight torpedoes and Exocet SM39 antiship missiles, these submarines can threaten high-value surface targets with little to no warning.⁶⁸ The eight Chinese-built *Hangor*-class submarines, planned for induction by the early 2030s, will significantly expand its conventional undersea capabilities.⁶⁹ While these will likely be used for conventional missions, including A2/AD, if even some are armed with Pakistan’s dual-capable Babur-3 SLCMs, adversaries will face uncertainty over which boats carry nuclear weapons.⁷⁰

61 Oriana Skylar Mastro, *Upstart: How China Became a Great Power* (Oxford: Oxford University Press, 2024), 101–102.

62 Chris Panella, “China Wants a Fleet of Aircraft Carriers for Pride and Power, and It’s Building It at a Breakneck Pace,” *Business Insider*, June 15, 2024, <https://www.businessinsider.com/why-china-wants-to-build-aircraft-carriers-2024-6>.

63 U.S. Department of Defense, *Military and Security Developments Involving the People’s Republic of China 2024: Annual Report to Congress* (Washington, DC: U.S. Department of Defense, 2024), 49, <https://media.defense.gov/2024/Dec/18/2003615520/-1/-1/0/MILITARY-AND-SECURITY-DEVELOPMENTS-INVOLVING-THE-PEOPLES-REPUBLIC-OF-CHINA-2024.PDF>.

64 *Ibid.*, 49, 54–55.

65 Tuneer Mukherjee, “Sino-Indian Maritime Competition: Shadow-Fighting in the Indian Ocean,” *Stimson Center*, July 19, 2020, <https://www.stimson.org/2020/sino-indian-maritime-competition-shadow-fighting-in-the-indian-ocean/>.

66 Darshana M. Baruah, “The Andaman and Nicobar Islands: India’s Eastern Anchor in a Changing Indo-Pacific,” *War on the Rocks*, March 21, 2018, <https://warontherocks.com/2018/03/the-andaman-and-nicobar-islands-indias-eastern-anchor-in-a-changing-indo-pacific/>.

67 Vipin Narang, *Nuclear Strategy in the Modern Era: Regional Powers and International Conflict* (Princeton, NJ: Princeton University Press, 2014), 19–20.

68 Rabia Akhtar, “Pakistan Navy’s Quiet Deterrence: Neutralizing India’s Maritime Signaling,” *Tribune Magazine*, August 10, 2025, <https://tribune.com.pk/story/2560610/pakistan-navys-deterrence-neutralising-indias-signaling>.

69 “Pakistan Navy Launches Third Hangor-Class Submarine PNS Mangro: Strategic Game-Changer Against India’s Kalvari Fleet,” *Defence Security Asia*, August 17, 2025, <https://defencesecurityasia.com/en/pakistan-navy-hangor-submarine-pns-mangro-vs-india-kalvari/>.

70 Betzalel Newman, “Nuclear Ambiguity in the Indian Ocean,” *Stimson Center*, April 30, 2025, <https://www.stimson.org/2025/>

Second, these SSKs are “equipped with advanced sensors and modern armaments, which tilts the tactical power balance slightly in favor of Pakistan,” aligning with its naval strategy of “offensive sea denial.”⁷¹ Rather than trying to control sea areas, which would somewhat be unrealistic given India’s larger fleet in the region, the goal is to deny the Indian navy free operation near Pakistan’s shores by using submarines and antiship missiles. In this context, the Pakistani military regards the nuclear-capable Babur-3 SLCM as providing “credible second-strike capability, augmenting existing deterrence” by holding high-value targets at nuclear risk, particularly given the “provocative nuclear strategies and postures being pursued in the neighborhood through the induction of nuclear submarines and ship-borne nuclear missiles.”⁷²

Third, Pakistan is heavily leveraging its close strategic ties with China to upgrade its navy. Along with the *Hangor*-class SSKs, Pakistan has acquired Type 054A/P frigates and other advanced platforms from China, which are intended to narrow the gap between it and the Indian navy—developments India has noted with concern.⁷³

Pakistan appears not to need to achieve ship-for-ship parity with India to create qualitative disadvantages and vulnerabilities for its neighbor in the near term. Indeed, India’s submarine fleet is larger, but none of its *Scorpène*-class submarines currently operate with AIP. Likewise, the development of an indigenous AIP program is facing delays, leaving the force at a stealth disadvantage.⁷⁴ As a result, CASD seems unachievable for India in the foreseeable future. As Russia’s Cold War experience shows, a bastion approach to deterrence can only be successful if the nuclear submarines are in heavily fortified and defended maritime bases under the protection of surface ships, conventional submarines, and maritime patrol aircraft. SSNs in particular play a vital role in safeguarding SSBNs by tracking and neutralizing potential threats, thereby enhancing the security and credibility of the sea-based deterrence mission.⁷⁵ Any gaps in these overlays—whether due to air and sensor constraints or an increase in adversaries’ A2/AD, AIP, and stealth capabilities—can undermine their security.

NAVAL EXERCISES, COALITION BUILDING, AND INDIA’S BROADER MARITIME STRATEGY

An important component of India’s maritime strategy and modernization is its closer cooperation with partners and friendly countries in the Indo-Pacific, particularly by conducting naval exercises to improve interoperability and strengthen security ties. For instance, the Quad’s Maritime Exercise Malabar 2024, hosted by India, featured complex anti-submarine, surface, and air defense drills to improve “situational awareness in the maritime domain.”⁷⁶ The first iteration, hosted by Australia in August 2023, included anti-submarine, air-defense, and gunnery exercises.⁷⁷ Another example is Varuna 2025, in which France’s *Charles de Gaulle* and India’s *Vikrant* conducted joint advanced drills and multidomain maneuvers in the Indian Ocean.⁷⁸

nuclear-ambiguity-in-the-indian-ocean/.

71 Gaurav Sen, “China Is Helping Modernize the Pakistan Navy. What Does That Mean for India?,” *The Diplomat*, July 22, 2023, <https://thediplomat.com/2023/07/china-is-helping-modernize-the-pakistan-navy-what-does-that-mean-for-india>.

72 Taheran, “Pakistan Advances Sea Leg of Triad.”

73 Sagar, “Navy Day Reminder.”

74 Swarajya, “India’s Submarine Upgrade Hits Another Wall,” *Swarajya*, August 4, 2025, <https://swarajyamag.com/defence/india-as-submarine-upgrade-hits-another-wall-drdo-aip-still-not-ready-as-pakistan-races-ahead>.

75 Roby Thomas, “Nuclear Attack Submarines: The Elixir for a True Blue-Water Navy,” *Journal of Defence Studies* 14, no. 4 (October–December 2020): 59–76, <https://www.idsa.in/system/files/jds/jds-14-4-2020-nuclear-attack-submarines.pdf>.

76 Indian Ministry of Defense, “Raksha Mantri Reviews Operational Preparedness of Indian Navy During Visit to Karwar,” press release, October 5, 2024, <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2062316&>.

77 Australian Ministry of Defense, “Exercise Malabar.”

78 Lariosa, “French, Indian Navies.”

These exercises have significant implications not only for increasing interoperability, strengthening mechanisms for maritime coordination, and ensuring warfighting readiness, but also for operationalizing India's sea denial in the IOR. Without deeper military collaboration, India risks having insufficient capacity to confront growing PLAN submarine activity and long-range deployments, especially as China's expanding naval presence in the region will soon surpass the ability of any single state to counter it.⁷⁹ Increasing naval exercises and coordination with partners allows effective burden sharing so that neither India nor its partners have to match China ship for ship. Instead, India can embed its modernization efforts within a partnership framework that enhances deterrence credibility by improving maritime domain awareness, complicating Chinese planning, and reassuring smaller states against coercion.

SOFT-POWER ASPECTS OF MODERNIZATION

Apart from hard power, India's modernization has also expanded its influence through maritime diplomacy, capacity building, and operations such as HADR, search and rescue (SAR), and non-combatant evacuation.⁸⁰ The Indian navy has consistently acted as a regional first responder, from its rapid response to the 2004 Indian Ocean tsunami to more recent missions such as Operation Rahat, which evacuated over 3,000 people from Yemen in 2015, and Operation Sahayata, in which three Indian navy ships were among the first responders to Mozambique after Cyclone Idai in 2019.⁸¹ These missions were only possible because of modernization investments in carriers, large amphibious ships, replenishment vessels, and surveillance assets that give India the necessary reach and coordination capacity.

Such operations are now core missions shaping modernization priorities. Under Modi's SAGAR doctrine, they serve as instruments of maritime diplomacy and regional leadership. As a result, new platforms such as the *Samarthak*-class multipurpose vessels are being designed with disaster relief functions in mind in addition to their traditional maritime security roles.⁸² Similarly, in 2018 the Indian navy established the Information Fusion Centre–IOR, which hosts 14 partner nations' liaison officers to help coordinate maritime domain awareness, SAR, and HADR.⁸³ These efforts show that India's maritime policy is not limited to deterrence or sea denial but also incorporates regional leadership and influence as core objectives. By continuing to invest in platforms and infrastructure that also enable HADR, SAR, and maritime diplomacy, India ensures its modernization efforts promote both hard and soft power.

CONCLUSION

While India has made significant progress in its naval modernization, important gaps remain. Investments in carriers, nuclear submarines, missile systems, and infrastructure have strengthened the country's ability to secure SLOCs, project power, and provide regional public goods under the SAGAR framework. Yet challenges in undersea survivability, delays in indigenous development programs, and limited carrier availability constrain its ability to fully realize its maritime ambitions.

79 Arzan Tarapore, "America Needs a Real Indian Ocean Strategy," *Foreign Affairs*, April 7, 2025, <https://www.foreignaffairs.com/ united-states/america-needs-real-indian-ocean-strategy>.

80 Indian Ministry of Defence (Navy), *Ensuring Secure Seas*, 98–101.

81 Ibid.; and Indian Ministry of External Affairs, "Humanitarian Assistance and Disaster Relief to Mozambique-Operation Sahayata 2019," press release, March 23, 2019, <https://www.mea.gov.in/press-releases.htm?dtl/31174/Humanitarian+As-sistance+and+Disaster+Relief+to+MozambiqueOperation+Sahayata+2019>.

82 "Indian Navy Lays the Keel of Two Multi-Purpose Vessels," *Naval News*, March 21, 2023, <https://www.navalnews.com/na-val-news/2023/03/indian-navy-lays-the-keel-of-two-multi-purpose-vessels/>.

83 "IFC-IOR," Information Fusion Centre-IOR, accessed September 4, 2025, https://ifcior.indiannavy.gov.in/about_us.

In addition, modernization alone cannot offset the scale of China's naval expansion or Pakistan's asymmetric escalation strategy. But just as India has used carrier construction to signal self-reliance and naval exercises with partners to build operational trust, it can mitigate these vulnerabilities by deepening interoperability with partners, accelerating anti-submarine warfare investments, and steadily advancing its indigenous programs.



Influence Without Nukes

Kazakhstan's Strategic Use of Nuclear Diplomacy to Advance Its National Interests

By Ayazhan Muratbek¹

INTRODUCTION

Debates on nuclear security often focus on nuclear-weapon states (NWSs), positioning them as the primary architects of the global nuclear order. However, as exemplified by Kazakhstan, nonnuclear-weapon states (NNWSs) can also play a significant role in shaping the norms and principles of nuclear governance. Through strategic narratives, these states not only influence global frameworks but also enhance their international status. Yet their contributions are often underestimated—an oversight that should be corrected, especially amid growing concerns over nuclear proliferation. These concerns stem not only from nonaligned states such as India and Pakistan but also from so-called rogue regimes, such as Iran and North Korea. Alarming, proliferation anxieties now extend even to the United States' allies, some of whom have begun contemplating their own nuclear capabilities.

Rising concerns in the United States over nuclear proliferation were notably intensified after China joined the nuclear club in 1964. This led to a stark conclusion from a task force created by President Lyndon B. Johnson: “Preventing the further spread of nuclear weapons is clearly in the national interest despite the difficult decisions that will be required.”² From that point onward, the United States has remained committed to both protecting its allies and persuading adversaries to support a global nuclear nonproliferation regime.

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 - 2 Ankit Panda, “Why America May Be Triggering a New Era of Nuclear Proliferation,” Chatham House, *The World Today* (Summer 2025), <https://www.chathamhouse.org/publications/the-world-today/2025-06/why-america-may-be-triggering-new-era-nuclear-proliferation>.

Following the collapse of the Soviet Union, the United States played an active role in assisting post-Soviet states in dismantling their nuclear arsenals and building sovereign governance structures aligned with their national interests. Kazakhstan, alongside Ukraine and Belarus, voluntarily relinquished its nuclear weapons, despite having on its territory the world's fourth-largest nuclear arsenal when the Soviet Union collapsed. While some may interpret this as either a product of external pressure from nuclear-armed powers or the naïveté of emerging states trading strategic assets for peace, the reality is far more complex. Although major powers exert significant influence on the formation of the global nuclear order, they do not control it entirely and are shaped by the same normative structures. The nuclear disarmament processes in Kazakhstan, Ukraine, and Belarus were guided by a long and nuanced engagement with international norms, legal frameworks, and diplomatic practices, all designed to align disarmament with national interest.

Kazakhstan's first president, Nursultan Nazarbayev, asserted that possessing nuclear weapons would not provide long-term security guarantees. He was convinced that maintaining a nuclear arsenal would hinder Kazakhstan's ability to establish constructive diplomatic relations and attract investment inflows. Today, Kazakhstan enjoys a stable international environment, with widespread recognition of its contributions to disarmament and nonproliferation—establishing it as a compelling example of how NNWSs can use nuclear diplomacy to assert influence on the global stage.

At the same time, Kazakhstan's decision to rid itself of nuclear weapons has not been without debate. Some argue that the country lost a critical lever of influence in modern geopolitics—an argument that has gained renewed relevance in light of Russia's nuclear threats against Ukraine. This context underscores the vital importance of NNWS leadership in maintaining international peace and security.

Focusing on Kazakhstan's nuclear diplomacy, this paper discusses how NNWSs develop their nuclear diplomacy as a unique advantage or “niche diplomacy” by exploring the following questions: How do NNWSs use nuclear diplomacy to maintain regional stability and advance national interests? What constitutes effective nuclear diplomacy for NNWSs? And what is the role—and implications—of nuclear diplomacy by these states in today's increasingly volatile geopolitical environment?

This paper begins by introducing the concept of nuclear diplomacy and explaining why some NNWSs adopt it as a form of niche diplomacy, including the advantages this strategy offers. It then outlines the conditions under which such diplomacy is effective and examines the broader implications of this foreign policy approach for the global nuclear order. This framework is subsequently applied to a case study on Kazakhstan's nuclear diplomacy. The paper concludes with key policy implications and a summary of the main findings.

This analysis holds significance for three main reasons. First, Kazakhstan serves as a successful example of how NNWSs can enhance their international standing and safeguard national interests without acquiring weapons of mass destruction. Second, in the context of Russia's increasing military assertiveness and China's growing nuclear capabilities, it illustrates how NNWSs can mitigate security risks without contributing to regional instability. Third, Kazakhstan's experience informs efforts by NNWSs and international organizations, such as the United Nations and the International Atomic Energy Agency (IAEA) to support NNWSs.

NUCLEAR DIPLOMACY AS A FORM OF “NICHE DIPLOMACY”

NUCLEAR DIPLOMACY

In general terms, diplomacy refers to the full range of a state’s actions aimed at achieving its foreign policy goals or, more simply, its approach to conducting international relations.³ It is a long-established practice that emerged from the necessity of finding cooperative solutions to global challenges that individual states cannot address or resolve on their own. By facilitating interactions across national borders, diplomacy inherently demands a degree of international governance. While international organizations play a key role in this process, effectively guiding them toward shared objectives also depends heavily on each country’s diplomatic efforts.

Joseph Nye, who coined the term soft power, described diplomacy as a powerful strategic tool through which weaker states can influence others to achieve desired outcomes, emphasizing the distinction between simply having resources and using them effectively.⁴ In fact, the diplomacy of smaller states, which often rely on soft power rather than material resources, illustrates that effectiveness in international politics depends as much on the context and strategic use of available tools as on the sheer availability of hard-power strategies that focus on coercive actions to enforce national interests.⁵

In the nuclear realm, diplomacy plays a crucial role in arms control, disarmament, the peaceful use of nuclear energy, and nonproliferation.⁶ Nuclear diplomacy typically involves interactions among states, international organizations, and nonstate actors, all with specific objectives shaped by national interests, the image they wish to project, and the norms they choose to uphold or reject.⁷ Through nuclear diplomacy, international actors help establish and enforce safeguards, verification principles for nuclear facilities, and state intentions, ensuring the security of nuclear materials and compliance with international norms related to the peaceful use of nuclear science and technology. Nuclear diplomacy is central to managing the global nuclear order, which is shaped by institutions, norms, and practices that regulate nuclear technologies, reinforce power structures, and foster meaningful political discourse on nuclear issues.⁸

The oldest form of nuclear diplomacy is atomic diplomacy, a term originally used to describe U.S. and Soviet foreign policies during the early years of the Cold War.⁹ This involved a more aggressive approach, using threats of nuclear war as leverage in diplomatic negotiations. For example, the United States at times attempted to use its nuclear monopoly to gain advantages in postwar diplomatic dealings with the Soviet Union.¹⁰ Although atomic diplomacy is rarely practiced today, some argue it helped prevent mutual assured destruction on multiple occasions during the Cold War.

3 Jean-Robert Leguey-Feilleux, *Global Governance Diplomacy: The Critical Role of Diplomacy in Addressing Global Problems* (Lanham, MD: Rowman & Littlefield, 2017).

4 Joseph S. Nye, “Soft Power: The Evolution of a Concept,” *Journal of Political Power* 14, no. 1 (2021): 196–208, <https://doi.org/10.1080/2158379x.2021.1879572>.

5 Kurt M. Cambell and Michael E. O’Hanlon, *Hard Power: The New Politics of National Security* (New York: Basic Books, 2006).

6 Jo-Ansie van Wyk, “Nuclear Diplomacy as Niche Diplomacy: South Africa’s Post-Apartheid Relations with the International Atomic Energy Agency,” *South African Journal of International Affairs* 19, no. 2 (2012): 179–200, <https://doi.org/10.1080/10220461.2012.706492>.

7 Ibid.

8 Kjølv Egeland, “The Ideology of Nuclear Order,” *New Political Science* 43, no. 2 (2021): 208–30, <https://doi.org/10.1080/07393148.2021.1886772>.

9 Robert Longley, “The Art of Atomic Diplomacy,” ThoughtCo., July 28, 2022, <https://www.thoughtco.com/atomic-diplomacy-4134609>.

10 Ibid.

However, the ongoing war in Ukraine has revived some of these dynamics, as Moscow increasingly uses existential threats as tactical tools in political negotiations.¹¹

Nuclear diplomacy today encompasses several distinct activities, which Abraham Bargman identifies as nuclear commerce, deterrence and extended deterrence, and the international control of atomic energy.¹² Modern international actors employ nuclear diplomacy strategically to manage international relations, advancing their security, economic interests, and political influence while balancing immediate priorities with broader global concerns. In recent years, a state's nuclear capabilities have become instruments of power, prestige, and diplomatic leverage.¹³

NICHE DIPLOMACY

Niche diplomacy is broadly understood as the practice of states selecting certain areas—such as peace mediation, nuclear nonproliferation, or humanitarian aid—that hold particular national importance or where they can make a unique contribution, and then focusing diplomatic efforts there through strategic entrepreneurship.¹⁴ Middle powers often pursue niche diplomacy, as they may lack the resources to engage in broad-based global diplomacy but can wield influence through focused engagement in small groups or multilateral institutions.¹⁵

There is no universally accepted definition of a middle power, as simple indicators such as population, GDP, and land area do not fully capture the concept. Robert Keohane suggested that middle powers are best defined by their behavior, describing them as states “whose leaders consider [that they] cannot act alone effectively but may be able to have a systemic impact in a small group or through an international institution.”¹⁶ The Middle Power Initiative, established in 1998 to support the abolition of nuclear weapons, defines such actors as “politically and economically significant, internationally respected countries that have renounced the nuclear arms race.”¹⁷

Nuclear diplomacy represents a particularly promising niche for middle powers like Kazakhstan to enhance their legitimacy and influence within the global nuclear order. By participating in nonproliferation regimes, promoting nuclear safety, and leveraging their technical expertise and normative commitments, these states can align their nuclear agendas with broader foreign policy goals.¹⁸ This illustrates how nuclear diplomacy can serve as an effective form of niche diplomacy and how it can shape the evolving nuclear order.

NUCLEAR DIPLOMACY AS NICHE DIPLOMACY FOR NNWSS

As noted above, middle power status is defined less by material indicators than by international influence. While countries with significant regional or global standing often have economic strength, diplomatic influence, and military capabilities, including nuclear weapons, possession of a nuclear

11 Rose Gottemoeller, “The Role of U.S. Diplomacy in Countering Russia’s Nuclear Threats and Misbehavior,” *Texas Nuclear Security Review* 6, no. 2 (Spring 2023), <https://tnsr.org/2023/03/the-role-of-u-s-diplomacy-in-countering-russias-nuclear-threats-and-misbehavior/>.

12 Abraham Bargman, “Nuclear Diplomacy,” *Proceedings of the Academy of Political Science* 32, no. 4 (1977): 159, <https://doi.org/10.2307/1173999>.

13 Rodney W. Jones, “Atomic Diplomacy in Developing Countries,” *Journal of International Affairs* 34, no. 1 (1980): 89–117.

14 Emmanuelle Maitre, “Nuclear Diplomacy: A Niche Diplomacy for Middle Powers,” *Researches and Documents* 8 (2018): 1–29, <https://www.frstrategie.org/sites/default/files/documents/publications/recherches-et-documents/2018/201808.pdf>.

15 Van Wyk, “Nuclear Diplomacy as Niche Diplomacy.”

16 Robert O. Keohane, “Lilliputians’ Dilemmas: Small States in International Politics,” *International Organization* 23, no. 2 (Spring 1969): 291–310, <https://www.jstor.org/stable/2706027>.

17 “History & Achievements,” Middle Powers Initiative, <https://www.middlepowers.org/history-achievements/>.

18 Maitre, “Nuclear Diplomacy: A Niche Diplomacy for Middle Powers.”

arsenal is a correlated rather than determinative trait of middle powers. Many middle powers are NNWSs, although this is not a rule. This paper does not explore the relationship between nuclear weapons possession and middle power status, but rather examines how NNWSs can use nuclear diplomacy as a form of niche diplomacy to advance their national interests and shape the global nuclear order.

As the central argument of this paper proposes, nuclear diplomacy allows NNWSs to pursue their national interests—security, political, economic, and identity-based—using normative, strategic, and economic instruments within the framework of the international nonproliferation regime. These interests are defined using a combined realist and constructivist lens: While the realist approach attributes physical survival, autonomy, and economic well-being to national interests, the constructivist concept adds another dimension of collective self-esteem, defined as the “group’s need to feel good about itself, for respect or status.”¹⁹

Survival is a fundamental concern for all states. As such, NNWSs may pursue nuclear diplomacy to strengthen the nonproliferation regime—essential for reducing nuclear risks—especially if they are located near NWSs, by proposing new norms, advocating for their enforcement and universalization, or facilitating their implementation through funding or institutional support.

Economically, nuclear diplomacy supports national development goals. Nuclear energy development has been a major incentive for NNWSs to engage diplomatically, but other economic benefits also motivate participation, including uranium exports, nuclear fuel production, and the manufacture of radioisotopes for medical or industrial use. States may also seek to influence trade rules related to technology transfer, export controls, and market access.

Politically, nuclear diplomacy enhances a state’s autonomy and international standing. For NNWSs, political independence often depends on a global order rooted in strong nuclear norms and collective security frameworks that do not rely on nuclear weapons. This gives them moral legitimacy in rejecting nuclear arms while portraying proliferators as pariah states.²⁰ Many nonnuclear middle powers increase their global influence through nuclear diplomacy, often by forming coalitions, such as the Nonproliferation and Disarmament Initiative, that help preserve their foreign policy autonomy and shape nuclear governance.

Finally, identity building is both a byproduct of and a motivation for nuclear diplomacy. Engaging in nuclear diplomacy allows NNWSs to present themselves as responsible global citizens and influence the values, institutions, and norms that govern international relations. Constructivists argue that state preferences are not fixed and that perceptions of nuclear weapons and technologies evolve over time.²¹ Changes in state behavior can result from shifts in cost-benefit calculations, persuasion, social conformity, norm internalization, or the desire to identify with a group of like-minded states. For more than 50 years, compliance with the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) has shaped state behavior and altered the cost-benefit calculus around nuclear development.

19 Alexander Wendt, *Social Theory of International Politics* (Cambridge, United Kingdom: Cambridge University Press, 1999), 236.

20 Maria Rost Rublee, *Nonproliferation Norms: Why States Choose Nuclear Restraint* (Athens, GA: University of Georgia Press, 2009), 17.

21 Ibid.

CASE STUDY: KAZAKHSTAN'S NUCLEAR DIPLOMACY

KAZAKHSTAN'S MOTIVATIONS FOR DISARMAMENT

Following the collapse of the Soviet Union, Kazakhstan inherited the world's fourth-largest nuclear arsenal, and together with other post-Soviet states held more than 3,000 strategic nuclear weapons and at least 3,000 tactical or battlefield nuclear weapons.²² In addition to nuclear warheads, Kazakhstan inherited dozens of heavy bombers, more than a hundred intercontinental ballistic missiles, tons of nuclear material, and related facilities. For the newly independent Republic of Kazakhstan, this was a critical period that required quick decisions about the future of these weapons and, more importantly, how to secure them in an environment of chaos and corruption.

Although the Soviet nuclear weapons stationed in Kazakhstan were officially recognized as the property of the Russian Federation, and Kazakhstan had no operational control over them, the situation regarding nuclear facilities and materials was different.²³ These assets were under Kazakhstan's jurisdiction, and in theory, Kazakhstan's leadership could have developed a latent nuclear capability. As a central component of the Soviet nuclear complex, more than 450 nuclear tests were conducted on its territory, and Kazakhstan possessed several nuclear research facilities, research reactors, and significant stockpiles of bomb-grade uranium. At one point, there was even debate about whether Kazakhstan could adopt the status of a "temporary nuclear state" to assert its sovereignty and gain leverage in international affairs.²⁴

However, Kazakhstan never had serious intentions to retain Soviet nuclear weapons. As Nazarbayev later recalled, the government did not hesitate to disarm, even declining financial support from figures such as Libyan leader Muammar al-Gaddafi, who hoped at least one Islamic state would maintain nuclear arms.²⁵ Nazarbayev emphasized that beyond humanitarian concerns, the decision was driven by a combination of security, economic, political, and diplomatic considerations.

The security rationale was especially compelling: Kazakhstan, bordered by nuclear powers like Russia and China, faced heightened vulnerability. Moreover, its bid to become a nuclear-armed state would have been strongly opposed by those same powers, as well as by the United States, which maintained that no new nuclear states should emerge from the Soviet collapse.²⁶ As Oumirserik Kassenov, a foreign policy adviser at the time, noted: "If drawn into a nuclear conflict of any sort, Kazakhstan faces a greater risk of being turned into ashes, being a nuclear state, than if it remains a nonnuclear one. There is absolutely no point in bringing the nuclear weapons into play even with purely defensive intentions in mind."²⁷

Economically, Kazakhstan faced a dire situation. The country lacked viable international and even domestic economic links and supply chains, which could be restored only through international

22 Kingston Reif, "The Lisbon Protocol at a Glance," Arms Control Association, last reviewed December 2020, <https://www.armscontrol.org/factsheets/lisbon-protocol-glance>.

23 Togzhan Kassenova, "Kazakhstan's Irreversible Disarmament," *Journal for Peace & Nuclear Disarmament* 7, no. 1 (2024): 60–70, <https://doi.org/10.1080/25751654.2024.2354951>.

24 Anuar Ayazbekov, "Kazakhstan's Nuclear Decision Making, 1991–92," *Nonproliferation Review* 21, no. 2 (2014): 149–168.

25 "Назарбаев Вспомнил о Предложенных Каддафи \$20 Млрд За Ядерное Оружие" [Nazarbayev recalled Gaddafi's offer of \$20 billion for nuclear weapons], RBC, July 16, 2021, <https://www.rbc.ru/politics/16/07/2021/60f1d9539a7947346cbb5289>.

26 Mariana Budjeryn, *Inheriting the Bomb: The Collapse of the USSR and the Nuclear Disarmament of Ukraine* (Johns Hopkins University Press, 2022), 92.

27 Oumirserik Kasenov, "The Fragile Future of the NPT," memo, 1992, author's translation, copy in author's possession; Oumirserik Kasenov, "Iadernoe oruzhie i bezopasnost' Kazakhstana," *Mysl'* no. 6 (1992): 25–28.

cooperation and investment—opportunities that would almost certainly be lost if it pursued a nuclear path.

Politically, support for nuclear weapons was minimal due to the deep trauma caused by decades of secret nuclear testing. This was powerfully symbolized by the antinuclear movement “Nevada-Semipalatinsk,” led by prominent writer and Soviet legislator Olzhas Suleimenov, which ultimately led to the closure of the Semipalatinsk Test Site. Kazakhstan’s decision to renounce nuclear weapons, along with associated infrastructure and materials, was a clear and irreversible act of disarmament.²⁸

KAZAKHSTAN’S NUCLEAR DIPLOMACY STRATEGIES

As discussed above, Kazakhstan faced numerous challenges in pursuing a nonnuclear path. While it had made progress in developing segments of the nuclear fuel cycle, including a robust uranium industry and a fuel fabrication plant, its capabilities were constrained by technical limitations, economic barriers, and geopolitical realities. These factors do not guarantee containment of a determined proliferator, but in Kazakhstan’s case they contributed to a nonnuclear trajectory.

Kazakhstan cooperated closely with both Russia and the United States to eliminate its nuclear arsenal, with dismantling operations carried out at Russian facilities and fissile material converted for use in nuclear power plants.²⁹ In return, the country received security assurances from nuclear powers and earned international respect, ultimately attracting over \$400 billion in foreign direct investment.³⁰ Rather than halting its nuclear engagement after disarmament, Kazakhstan emerged as a proactive advocate of nuclear disarmament and nonproliferation worldwide.

Shortly after gaining independence in 1991, Kazakhstan, alongside Belarus and Ukraine, joined the Strategic Arms Reduction Treaty (START I) and signed the Lisbon Protocol, initiating the process of nuclear disarmament. These agreements recognized the three states as legitimate successors to Soviet nuclear arsenals and committed them to eliminating all strategic nuclear weapons, including delivery systems, exceeding START I’s baseline reductions.³¹

The United States played a major role through the Nunn-Lugar Cooperative Threat Reduction (CTR) program, supporting Kazakhstan’s disarmament due to its limited ability to store and transport nuclear weapons securely. The CTR program extended across all three post-Soviet states and, in Kazakhstan’s case, enabled the safe transfer of warheads and delivery systems, the destruction of strategic infrastructure, and the secure management of nuclear materials.³²

A particularly sensitive task involved the removal of highly enriched uranium. This was accomplished during the covert joint mission Operation Sapphire, during which approximately 600 kg of weapons-grade nuclear material was airlifted from the Ulba Metallurgical Plant to the United States. Senators Sam Nunn (D-GA) and Richard Lugar (R-IN), bipartisan architects of the CTR program, viewed such efforts as vital to U.S. and global security.³³

28 Kassenova, “Kazakhstan’s Irreversible Disarmament.”

29 Ibid.

30 Azamat Syzdykbaev, “Что Дал Казахстану Отказ От Ядерного Оружия, Рассказал Нурсултан Назарбаев” [What the refusal of nuclear weapons gained for Kazakhstan, Nursultan Nazarbayev reveals], Kazinform, November 17, 2021, https://www.inform.kz/ru/chto-dal-kazakhstanu-otkaz-ot-yadernogo-oruzhiya-rasskazal-nursultan-nazarbaev_a3863498.

31 Budjeryn, *Inheriting the Bomb*, 84.

32 Viktor Krai, “Безъядерная Держава. Часть 3: Зачем Казахстан Отказался От Ядерного Оружия” [Nuclear-free state. Part 3: Why Kazakhstan renounced nuclear weapons], Masa Media, December 21, 2023, <https://masa.media/ru/site/bezyadernaya-derzhava-chast-3-zachem-kazakhstan-otkazalsya-ot-yadernogo-oruzhiya>.

33 Ibid.

The Semipalatinsk Test Site, Kazakhstan's largest and most notorious nuclear facility, was also fully decommissioned. After assuming control of the site, Kazakhstan sealed underground test shafts, dismantled weapons infrastructure, and undertook radiation mitigation efforts.³⁴ This required significant work, since the Russian specialists who worked at the test sites left after the collapse of the Soviet Union without giving the Kazakh government any information about the locations of many tunnels and boreholes. This particularly alarmed American scientists at Los Alamos National Laboratory, who subsequently proposed Project Amber, a joint Kazakh-American-Russian project to further support Kazakhstan in eliminating sources of weapons-grade material at the test site.³⁵ These efforts included operations such as sealing test shafts, filling large explosion chambers known as "kolbas" with easily recoverable plutonium, and removing highly sensitive bomb components from certain areas of the test site. The formally secret Trilateral Threat Reduction Cooperation program was first announced at the 2012 Seoul Nuclear Security Summit by U.S. President Barack Obama, Russian President Dmitry Medvedev, and Nazarbayev. In the 2000s, the Semipalatinsk Test Site was repurposed as the National Nuclear Center of Kazakhstan, tasked with eliminating sensitive technologies that enable nuclear weapons and advising the government on peaceful uses of nuclear energy.³⁶

By April 1995, all 1,410 Soviet-era warheads had been removed from Kazakhstan's territory or destroyed using chemical processes at testing sites.³⁷ Kazakhstan acceded to the NPT in 1994 and became one of the first countries to sign the Comprehensive Nuclear-Test-Ban Treaty (CTBT) in 1996, ratifying it in 2001. Demonstrating continued leadership, Kazakhstan helped establish a Central Asian Nuclear-Weapon-Free Zone, which entered into force on March 21, 2009. It remains the only former Soviet republic to both sign the Treaty on the Prohibition of Nuclear Weapons (TPNW) and ratify the Convention on Nuclear Safety.

Kazakhstan also championed the commemoration of August 29, which is the date of the first Soviet nuclear test, as the UN-recognized International Day Against Nuclear Tests and launched the global advocacy campaign known as ATOM (Abolish Testing. Our Mission).³⁸

In parallel with denuclearization efforts, Kazakhstan prioritized peaceful nuclear development. In 1993 and 1994, it invited the IAEA to assess its infrastructure, leading to long-term cooperation that has resulted in large-scale projects such as the establishment of the IAEA Low Enriched Uranium (LEU) Bank in Kazakhstan in 2015.³⁹ The idea for such a facility arose due to the risks of proliferation of enrichment technologies that could be used to develop nuclear weapons. The LEU Bank was intended to meet the needs of a growing number of countries interested in nuclear energy by guaranteeing LEU supplies while creating an option for countries not to develop uranium enrichment capacity. IAEA member states voted to establish the fuel bank in December 2010, selecting Kazakhstan, the world's largest uranium ore producer with a licensed nuclear facility suitable for large-scale operations and full infrastructure, as the most suitable location.⁴⁰ In 2019, the fuel bank

34 Kassenova, "Kazakhstan's Irreversible Disarmament."

35 "Semipalatinsk Test Site," Nuclear Threat Initiative, <https://www.nti.org/education-center/facilities/semipalatinsk-test-site/>.

36 "Kazakhstan's Contribution to Nuclear Disarmament, Non-Proliferation and Peaceful Use of Nuclear Energy," Government of the Republic of Kazakhstan, August 17, 2021, <https://www.gov.kz/memleket/entities/mfa-aman/press/article/details/59812?lang=en>.

37 Ibid.

38 "International Day Against Nuclear Tests," United Nations, n.d., <https://www.un.org/en/observances/end-nuclear-tests-day>.

39 "IAEA Low Enriched Uranium (LEU) Bank," IAEA, accessed September 30, <https://www.iaea.org/topics/iaea-low-enriched-uranium-bank>.

40 "International IAEA LEU Bank," Nuclear Threat Initiative, n.d., <https://www.nti.org/about/programs-projects/project/inter->

received its first batch of uranium in a purpose-built storage facility at the Ulba Metallurgical Plant in eastern Kazakhstan.⁴¹

While Kazakhstan inherited key components of the Soviet fuel cycle, it has shown no interest in sensitive technologies such as enrichment or reprocessing.⁴² Public skepticism toward nuclear energy, rooted in painful historical experiences, remains strong. However, the government has recently made serious moves to build nuclear power plants to meet growing electricity demand, partnering with Russia's state-owned nuclear energy company Rosatom to begin building the first plant, and with state-owned China National Nuclear Corporation to build the second and third plants.⁴³ Such initiatives are unlikely to raise proliferation concerns, given Kazakhstan's firm disarmament record and commitment to nonproliferation diplomacy.⁴⁴

All of these actions reflect Kazakhstan's consistent and pragmatic approach to nuclear diplomacy. For NNWSs, a balanced foreign policy that engages key global stakeholders is often essential. While other countries, such as Brazil and Austria, also advocate for nuclear disarmament treaties, Kazakhstan's strategy stands out for its comprehensiveness. It blends political legitimacy, technical capacity, and strong diplomatic will to create a credible and multidimensional nuclear diplomacy framework.⁴⁵

By pursuing strategically advantageous policies as an NNWS, Kazakhstan has positioned itself as a bridge between nuclear and nonnuclear states, earning symbolic and institutional recognition on the global stage. It has hosted major events such as the Nuclear Security Summit, the International Physicians for the Prevention of Nuclear War Congress, and the International Anti-Nuclear Conference.⁴⁶ Kazakhstan also chaired the Hague Code of Conduct against ballistic missile proliferation (2016–2017) and sought a position on the IAEA Board of Governors, culminating in its successful campaign for a nonpermanent seat on the UN Security Council (2017–2018). In December 2023, the UN General Assembly approved for the first time three Kazakh-initiated resolutions on global security, disarmament, and the nonproliferation of weapons of mass destruction, affirming the country's status as a responsible NNWS and a leader among developing states.⁴⁷ Moreover, Kazakhstan chaired the Second Preparatory Committee for the Eleventh Review Conference of the Parties to the NPT in the summer of 2024 for the first time, marking a return to positive negotiating dynamics at the key platform in the field of nuclear disarmament and nonproliferation.⁴⁸

From day one, as the heir to Soviet nuclear weapons, it was critical for Kazakhstan to develop balanced nuclear policy strategies that would turn the need for disarmament into an advantage,

national-nuclear-fuel-bank/.

41 "IAEA Fuel Bank Receives First Delivery of Uranium," World Nuclear News, October 18, 2019, <https://www.world-nuclear-news.org/Articles/IAEA-fuel-bank-receives-first-delivery-of-uranium>.

42 Kassenova, "Kazakhstan's Irreversible Disarmament."

43 Merhat Sharipzhan and RFE/RL's Kazakh Service, "Kazakhstan's Atomic Maneuvers: Astana Tilts Toward Beijing in Its Nuclear Energy Ambitions," Radio Free Europe/Radio Liberty, August 7, 2025, <https://www.rferl.org/a/kazakhstan-china-russia-nuclear-diplomacy/33495107.html>.

44 Ibid.

45 Emmanuelle Maitre, "Kazakhstan's Nuclear Policy: An Efficient Niche Diplomacy?," *Fondation pour la Recherche Stratégique*, Note no. 10 (July 1, 2018), <https://inis.iaea.org/records/9kws0-qmd16>.

46 Ibid.

47 Dana Omirgazy, "UN General Assembly Approves Three Resolutions on Global Security Proposed by Kazakhstan," *Astana Times*, December 4, 2024, <https://astanatimes.com/2024/12/un-general-assembly-approves-three-resolutions-on-global-security-proposed-by-kazakhstan/>.

48 "Second NPT Preparatory Committee in Geneva: Kazakhstan Strengthens Global Nuclear Security," *Astana Times*, August 6, 2024, <https://astanatimes.com/2024/08/second-npt-preparatory-committee-in-geneva-kazakhstan-strengthens-global-nuclear-security/>.

ensuring security guarantees and global recognition as a sovereign state while promoting economic growth and gaining international credibility. Perhaps most importantly, Kazakhstan's commitment to nonproliferation and disarmament has shaped its national identity, fostering state and public support for a world free of nuclear weapons.

IMPACT OF PUTIN'S WAR OF AGGRESSION

In recent years, the debate over whether Kazakhstan should have relinquished its nuclear weapons has resurfaced, particularly in light of Vladimir Putin's demonstrative aggression against Ukraine, which began with the annexation of Crimea in 2014. Some in Kazakhstan fear that a "Ukrainian scenario" could unfold in their own country, which shares a long border with Russia and is home to a significant ethnic Russian population. Similar discussions are ongoing in Ukraine, where some argue that had the country retained its nuclear weapons, Russia might have been deterred from attacking.

The Budapest Memorandum, signed on December 5, 1994, gave Kazakhstan, Ukraine, and Belarus the confidence to surrender their strategic nuclear arsenals in exchange for security assurances from Russia, the United States, and the United Kingdom—assurances that Russia has blatantly violated.⁴⁹

Marking its 30th anniversary last year, the Budapest Memorandum had long been celebrated as a successful example of international nuclear dispute resolution and a landmark moment in the arms control movement.⁵⁰ However, many view the memorandum as dangerously ambiguous. It is not a legally binding agreement but rather a political document reflecting security "assurances" rather than enforceable "guarantees." It promised respect for the independence and sovereignty of the three newly independent states and reaffirmed the pledge of NWSs under the NPT not to use or threaten to use nuclear weapons against NNWSs. These objectives were formalized through the countries' accession to the NPT.

Russia's blatant disregard for its obligations under the Budapest Memorandum has significantly eroded trust in international agreements and undermined the credibility of security assurances. At the same time, the international community should recognize that although the memorandum lacked ratification and legal force, it reaffirmed and politically reinforced the UN Charter, which had already been signed by all the parties and legally bound them to respect the territorial integrity and sovereignty of any state. By invading Ukraine, Russia blatantly violated its obligations under both a legally binding treaty and a political commitment. Thus, it is not the mere existence of the document that provides the ultimate guarantee; it is the commitment and responsible conduct of its signatories.

Kazakhstan's decision to denuclearize and join the global nonproliferation regime was a calculated and strategic component of its nuclear diplomacy. Along with Ukraine and Belarus, Kazakhstan chose disarmament to safeguard its sovereignty and territorial integrity, attract foreign investment and technology, gain access to global markets, and cultivate positive relations within the international community. The assertiveness of Kazakh leaders in negotiating the terms of nuclear dismantlement was not a serious attempt to preserve a nuclear deterrent but rather a strategic maneuver to secure these broad benefits. Ultimately, Kazakhstan achieved all of this, and had it attempted to retain nuclear weapons outside the established nonproliferation norms, it would have risked becoming

49 "Ukraine, Nuclear Weapons, and Security Assurances at a Glance," Arms Control Association, March 2022, <https://www.armscontrol.org/factsheets/ukraine-nuclear-weapons-and-security-assurances-glance>.

50 Robert Lawless, "Ukraine Symposium—the Budapest Memorandum's History and Role in the Conflict," Lieber Institute West Point, *Articles of War*, January 15, 2025, <https://lieber.westpoint.edu/budapest-memorandums-history-role-conflict/>.

an international pariah.⁵¹ Furthermore, choosing a nonnuclear path was essential for shaping Kazakhstan's national identity. It marked a conscious break from the Soviet nuclear legacy, which had inflicted lasting harm on the Kazakh people.

In the early 1990s, the three post-Soviet states inherited massive nuclear arsenals amid weak institutions, poor economic conditions, and limited legal authority. In this context, disarmament was a rational and strategic decision. There is also a common misconception that the Soviet-era warheads located in these countries could serve as a deterrent against Russia. However, historical records show that those weapons were targeted at the United States and could not be safely maintained by the newly independent states.⁵² The United States, therefore, had a shared interest with Russia in preventing the emergence of new nuclear powers in the post-Soviet space.

Whether disarmament was ultimately the "right" choice in hindsight—given that one of the guarantor states has flagrantly violated its commitments—is a separate and complex question. It casts serious doubt on the reliability of security assurances in an anarchic international system. The case of Ukraine also has troubling implications for the NPT, as it undermines the credibility of the security guarantees offered to NNWSs and threatens to weaken global nonproliferation efforts.

Since Russia's initial aggression against Ukraine in 2014, Kazakhstan has had reason to reevaluate the credibility of the Budapest Memorandum. Kazakh authorities should take note of how Ukrainian leaders are using the memorandum's failure to argue for a new, upgraded security architecture. For instance, under its 10-point peace plan, also known as the Kyiv Security Compact, Ukraine is seeking legally binding security guarantees strong enough to deter and repel future aggression from Russia.⁵³

While debates questioning the credibility of the Budapest Memorandum have subsided slightly in Kazakhstan due to its increased dependence on its northern neighbor, Astana has taken a number of moderate steps to distance itself from Moscow following the full-scale invasion of Ukraine. It has publicly refused to recognize the Luhansk and Donetsk regions as Russian territory and affirmed its commitment to international law, norms, and compliance with Western sanctions.⁵⁴ Simultaneously, Kazakhstan has strengthened its ties with China as part of a broader strategy to balance its relationship with Russia. In April 2022, Chinese President Xi Jinping issued a rare public statement reaffirming China's support for Kazakhstan's independence, sovereignty, and territorial integrity, emphasizing political stability, economic development, and opposition to external interference. The message was clearly directed at Moscow.

Moreover, despite the tense situation in the region, Kazakhstan has publicly reaffirmed its stance on nuclear weapons in recent years. In 2022, Kazakh leaders called for the global elimination of nuclear weapons by 2045, citing the conflict in Ukraine as a driving motivation.⁵⁵ In an article

51 Chris Rickleton, "Despite Russian Invasion of Ukraine, Moscow's Neighbors Correct to Give up the Bomb, Says Kazakh Author," Radio Free Europe/Radio Liberty, October 30, 2022, <https://www.rferl.org/a/kazakhstan-nuclear-russia-arsenal-ukraine/32107639.html>.

52 Svetlana Savranskaya and Tom Blanton, "The Budapest Memorandum 1994 After 30 Years: Non-Proliferation Success Overshadowed by NATO Blowup Then, Russian War on Ukraine Now," National Security Archive, December 5, 2024, <https://nsarchive.gwu.edu/briefing-book/nato-75-russia-programs/2024-12-05/budapest-memorandum-1994-after-30-years-non>.

53 Mykhailo Soldatenko, "Constructive Ambiguity of the Budapest Memorandum at 28: Making Sense of the Controversial Agreement," Lawfare, February 7, 2023, <https://www.lawfaremedia.org/article/constructive-ambiguity-of-the-budapest-memorandum-at-28-making-sense-of-the-controversial-agreement>.

54 Chan Young Bang and Anar Shaikenova, "Three Years of War in Ukraine: The Impact on Kazakhstan and the Uncertain Path Forward," The Geopolitics, April 5, 2025, <https://thegeopolitics.com/three-years-of-war-in-ukraine-the-impact-on-kazakhstan-and-the-uncertain-path-forward/>.

55 "Казахстан Предложил к 2045 Году Ликвидировать Ядерное Оружие" [Kazakhstan proposes to eliminate nuclear weap-

timed to coincide with the first meeting of states parties to the TPNW in Vienna in the summer of 2022, Mukhtar Tileuberdi, Kazakhstan's foreign minister at the time, acknowledged that the debate over the development and use of nuclear weapons amid the war in Ukraine compelled the Kazakh government, more than ever, to consider the urgent need to ban and eliminate these deadly weapons.⁵⁶ In a statement the following year, Kazakh President Kassym-Jomart Tokayev reiterated the government's belief that Kazakhstan does not need nuclear weapons, citing its commitment to the NPT and TPNW, and stated that there is no need for his country to join the Union State of Russia and Belarus, rejecting a proposal from Belarusian President Alexander Lukashenko.⁵⁷

Ultimately, the weakening of the Budapest Memorandum underscores the risks of relying too heavily on unenforceable security assurances. It reinforces the broader argument that NNWSs should pursue nuclear diplomacy not merely as a moral or legal obligation, but as a strategic tool to safeguard their national interests. While the memorandum serves as a cautionary example of the limits of international guarantees, it also highlights the urgent need to formalize and legalize security arrangements in the context of disarmament, perhaps by reducing the level of ambiguity in the nature and terms of such commitments.

CONCLUSION

Since their invention, nuclear weapons have been regarded as the ultimate symbol of power and strength in international relations. A vast literature has explored the motives that drive states to pursue a nuclear path, from the fundamental goal of national security to narrower and less obvious strategies based on political calculations. The range of such varied motivations for nuclear proliferation is compounded by the fact that international nonproliferation norms and practices no longer (and perhaps never did) constrain states from considering nuclear arsenals. In addition to growing great power competition and adversaries' increasing disregard for existing arms control frameworks, the international community in today's security environment must refocus attention on NNWSs, to ensure that their commitment to nonnuclear status continues to outweigh the perceived geopolitical benefits of possessing nuclear weapons.

Kazakhstan took an irreversible step toward disarmament with its historic decision to renounce nuclear weapons through transparent dismantlement efforts and responsible engagement in nuclear diplomacy. The country serves as a compelling example to states in a similar position, demonstrating the power of nuclear diplomacy that allowed the country to independently join the NPT as a NNWS despite arguments for retaining a nuclear arsenal to protect its sovereignty. The country's diplomatic strategy in the 1990s was based on a sober assessment of geopolitical realities and a determination to ensure its national interests, security, and socioeconomic development. Studying Kazakhstan's nuclear legacy is vital given its geographic location between Russia and China—two major nuclear powers. States and international organizations can learn much from Kazakhstan's carefully crafted nuclear diplomacy, which combines political legitimacy, technical capacity, and strong diplomatic will to create a robust and multidimensional nuclear diplomacy framework.

ons by 2045], *Radio Azattyq*, June 19, 2022, <https://rus.azattyq.org/a/31904929.html>.

56 Mukhtar Tileuberdi, "Договор о запрещении ядерного оружия – новая реальность в процессе ядерного разоружения" [The Treaty on the Prohibition of Nuclear Weapons – a new reality in the process of nuclear disarmament], *Liter*, June 18, 2022, <https://liter.kz/dogovor-o-zapreshchenii-iadernogo-oruzhii-novaia-realnost-v-protsesse-iadernogo-razoruzheni-ia-mukhtar-tleuberdi-1655549729/>.

57 Iryna Balachuk, "Kazakhstan's President Declines Lukashenko's Offer to Join the Union State of Russia and Belarus," *Ukrainska Pravda*, May 29, 2023, <https://www.pravda.com.ua/eng/news/2023/05/29/7404326/>.



Dangerous by Design

Reconstructing North Korea's Nuclear Command and Control and Its Implications for Deterrence and Crisis Stability

By Shawn Rostker¹

North Korea's emergence as a de facto nuclear-armed state raises urgent questions about how its nuclear forces are managed and controlled. Pyongyang has tested multiple nuclear devices and an array of ballistic missiles, demonstrating the capability to strike targets throughout East Asia and quite likely the U.S. mainland. Yet the inner workings of North Korea's nuclear command and control (NC2) system remain opaque. Who would authorize and execute a North Korean nuclear strike? How are launch orders transmitted? What safeguards (if any) exist to prevent accidental or unauthorized use? These are not academic questions. The answers shape the credibility of North Korea's deterrent and the risk of nuclear disaster on the Korean Peninsula. As Kim Jong-un rapidly expands and refines his arsenal, North Korea's NC2 architecture—the “transmission belt” that operationalizes North Korea's nuclear strategy—appears dangerous by design. Its structural features may heighten the chance of miscalculation and escalation, complicating deterrence and crisis stability in East Asia.

This paper seeks to map North Korea's NC2 system using open-source information and assess its implications for strategic stability. It builds on previous analyses and integrates new insights from comparative NC2 frameworks, regional expert commentary, and North Korea's own doctrinal statements. Nevertheless, any attempt to reconstruct North Korea's NC2 system must acknowledge the inherent limitations of open-source analysis. Due to Pyongyang's deliberate opacity and the paucity of verifiable information, assessments necessarily involve analytic gaps and should be treated as provisional rather than definitive.

1 Shawn Rostker is a research analyst with the Center for Arms Control and Non-Proliferation. The views expressed in this paper are those of the author and do not reflect the views of his employer.

This study finds that Pyongyang's NC2 is shaped by competing imperatives: an acute external threat environment that incentivizes "positive control," ensuring nuclear weapons can be used quickly if ordered, and an authoritarian political structure that demands "negative control," preventing any use not expressly authorized by Kim. Reconciling these goals is inherently problematic. In peacetime, Kim maintains highly centralized personal authority over all nuclear decisions, favoring tight negative controls such as keeping warheads separated from delivery systems and limiting launch access to only his most trusted officers. However, as a crisis unfolds, the regime faces pressure to delegate nuclear use authority or else risk losing its arsenal in a first strike. Evidence suggests that in wartime North Korea's command system might shift toward a "fail-deadly" posture, in which lower-level commanders are preauthorized to launch if the leadership is incapacitated.² This transition, from rigid central control to rapid delegation under fire, would create dangerous instability at the very moment nuclear use becomes most likely.

North Korea's nuclear policy law, passed in September 2022, underscores this dilemma. The law reaffirmed Kim's sole authority over nuclear weapons but also stipulated that if the NC2 system comes under threat, nuclear strikes would be initiated "automatically."³ In essence, Pyongyang codified a doomsday mechanism: The regime signaled that any attempt to decapitate its leadership will trigger nuclear retaliation, even if launch orders cannot be transmitted through normal chains. While intended to shore up deterrence, such provisions also reduce deliberation in a crisis, potentially permitting a hair-trigger launch on warning or upon loss of communications.⁴

COMPARATIVE FRAMEWORKS FOR NUCLEAR COMMAND AND CONTROL

Every nuclear-armed state must contend with the classic "always/never dilemma": Nuclear forces must always be ready to fire when authorized, but never be used without proper authorization.⁵ Achieving the right balance of positive and negative control is a fundamental challenge. Emerging nuclear states often face intense security threats and lack sophisticated control technologies, causing them to lean toward one extreme or the other. In practice, a country's threat perceptions, regime type, strategic culture, and technological sophistication all shape where it falls on the NC2 spectrum.

Scholars delineate two broad approaches: Assertive-control regimes emphasize tightly centralized oversight and fail-safe mechanisms to ensure weapons never launch without explicit permission, whereas delegative-control regimes accept greater military autonomy and incorporate fail-deadly features so that weapons can be used even under duress.⁶ New nuclear powers rarely achieve a perfect equilibrium but instead make trade-offs based on which failure mode they deem more dangerous:

2 Shane Smith and Paul Bernstein, *North Korean Nuclear Command and Control: Alternatives and Implications* (New York: National Defense University, 2022), https://wmdcenter.ndu.edu/Portals/97/Documents/Publications/NK-Nuclear-Command-and-Control_Report.pdf.

3 Josh Smith, "Kim Jong Un's 'Decapitation' Fears Shine Through New North Korea Nuclear Law," Reuters, September 9, 2022, <https://www.reuters.com/world/asia-pacific/kim-jong-uns-decapitation-fears-shine-through-new-nkorea-nuclear-law-2022-09-09/>.

4 Launch on warning (LOW) refers to a nuclear posture in which a state's leadership authorizes the launch of nuclear weapons upon receiving reliable warning of an incoming nuclear attack—but before those enemy warheads actually detonate. This strategy depends on early-warning systems capable of detecting a launch in real time and rapidly verifying it. The goal is to prevent a disarming first strike by ensuring retaliatory capability even if the attack is already in flight.

5 Peter D. Feaver, "Testimony before the Senate Foreign Relations Committee on U.S. Nuclear Command and Control," Duke University Spotlight, November 14, 2017, https://spotlight.duke.edu/governmentrelations/wp-content/uploads/sites/54/2020/05/111417_Feaver_Testimony.pdf.

6 Ibid.

unauthorized launch or an inability to launch when needed. Importantly, the optimization of NC2 is not a challenge unique to new nuclear states. Even mature nuclear powers like the United States tolerate operational trade-offs across their arsenals, including periods of reduced redundancy or latency. As has been noted, no NC2 system is entirely fail-safe or fully optimized across all conditions.⁷

One major factor driving these trade-offs is the external threat environment. States facing existential or overwhelming conventional threats often prioritize credible use (positive control) at the expense of stringent safety measures, while states in less dire positions can afford tighter negative control.⁸ For example, a state pursuing an “asymmetric escalation” posture (i.e., Pakistan vis-à-vis India) deploys nuclear weapons for potential first use early in a conflict, which in turn necessitates a more delegative command system during crises to ensure those weapons can indeed be launched quickly if ordered.⁹

Conversely, a state with an “assured retaliation” posture (i.e., China, historically) plans for second strike only and thus favors assertive control, where warheads are typically kept off alert and launch decisions are tightly centralized, accepting a slower response in exchange for reducing accidental-use risk. North Korea’s evolving nuclear strategy increasingly resembles an asymmetric escalation posture aimed at deterring U.S. and South Korean conventional superiority by threatening early nuclear strikes.¹⁰ This logically means Pyongyang would feel pressure in a crisis to adopt positive-control measures such as predelegating launch authority or automating certain responses to ensure its threats are credible when facing imminent attack.

Regime type and strategic culture are equally critical. A nation’s internal political structure dictates who controls the bomb. North Korea is an extreme case. It is a personalist authoritarian system in which all authority flows from Kim Jong-un as supreme leader, and it has a state ideology that demands absolute loyalty with zero tolerance for independent military decisionmaking. This predisposes Pyongyang toward highly centralized, assertive control of nuclear weapons under Kim’s direct command. Indeed, Kim’s deep suspicion of his own military and political establishments and fear of internal coups, exemplified by purges and public executions of those deemed disloyal or a threat to the regime, likely make him averse to predelegating launch authority except *in extremis*.

By contrast, other nuclear-armed nations have shown variation. For instance, Pakistan’s military-dominated regime keeps tight centralized control in peacetime but is believed to allow some delegation to field commanders in a crisis to enable rapid response to Indian provocation.¹¹ China’s leadership, facing less immediate threat, historically practiced strict negative control by keeping warheads disassembled or separated and launch decisions confined to the top echelon within a collegial party framework. North Korea, however, combines the worst of both worlds: Its security situation is more precarious than China’s (pushing it toward a hair-trigger, warfighting stance), but its political DNA is even more autocratic than Pakistan’s (pulling it toward centralized micromanagement). The result appears to be a Frankenstein’s monster NC2 system—one that in

7 Peter D. Feaver, *Guarding the Guardians: Civilian Control of Nuclear Weapons in the United States* (New York: Cornell University Press, 1992).

8 Vipin Narang and Ankit Panda, “Command and Control in North Korea: What a Nuclear Launch Might Look 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>.

9 Vipin Narang, *Nuclear Strategy in the Modern Era: Regional Powers and International Conflict* (Princeton, NJ: Princeton University Press, 2014), <https://doi.org/10.2307/j.ctt6wq00j>.

10 Ibid.

11 Michael Krepon, Rodney W. Jones, and Ziad Haider, eds. *Escalation Control and the Nuclear Option in South Asia* (Washington, DC: Henry L. Stimson Center, November 2004), https://www.stimson.org/wp-content/files/file-attachments/Escalation%20Control%20FINAL_0.pdf.

peacetime is among the most centralized in the world, yet in wartime could rapidly become one of the most dangerously decentralized.

NORTH KOREA'S NUCLEAR COMMAND AND CONTROL ARCHITECTURE

SUPREME LEADERSHIP AND LAUNCH AUTHORITY

At the apex of North Korea's NC2 is Kim Jong-un himself. North Korean doctrine and official statements leave no doubt that Kim, as supreme commander of the Korean People's Army (KPA) and head of state, holds the sole authority to approve nuclear weapons use. The country's April 2013 law establishing its status as a nuclear-armed state explicitly stated that nuclear weapons can be used only on orders of the supreme commander, and Kim's subsequent remarks have continually reinforced his personal control.¹² In practical terms, this means the decision to fire a nuclear warhead, whether in testing or in combat, is concentrated entirely in Kim's hands. Subordinate commanders, regardless of rank, cannot initiate a nuclear launch on their own. This top-down authority reflects Kim's desire to centralize nuclear decisionmaking and prevent any use that he does not direct.

The institutional channels through which Kim's launch orders would flow remain opaque.¹³ It's possible that Kim would issue a direct order through the Central Military Commission (CMC) of the Workers' Party or via the State Affairs Commission, possibly in the form of a coded message to the relevant missile units. Still, it is also possible that a dedicated nuclear command staff exists within the KPA General Staff Department or the Ministry of Defense to convey and execute nuclear orders on Kim's behalf.¹⁴ What little open-source evidence exists suggests that Kim's personal involvement is required at multiple stages of any nuclear operation.

For example, North Korean state media imagery from missile exercises routinely shows Kim present to supervise and give the final go-ahead for launches, particularly launches simulated to deliver nuclear warheads in training scenarios.¹⁵ This suggests that in peacetime Pyongyang maintains an assertive control model in which no nuclear weapon can be used unless Kim himself authorizes it. It aligns with the regime's broader cult of personality and extreme civil-military distrust that a single man monopolizes nuclear release authority.

Such centralized control, however, raises obvious risks. If Kim were killed or cut off from communication, could North Korea's nuclear forces function? The regime publicly insists that its nuclear arsenal is secure under Kim's firm hand, but it also hints at contingency plans for automatic or predelegated launch authority in extremis. The September 2022 nuclear law, for instance, implies that if Kim is incapacitated or the command system is disabled, nuclear strikes will proceed regardless. This duality—Kim as the only decisionmaker in normal times, yet provisions for others to

12 Korean Central News Agency, "Law on Consolidating Position of Nuclear Weapons State Adopted," KCNA Watch, April 1, 2013, <https://kcnawatch.org/newstream/1451896124-739013370/law-on-consolidating-position-of-/>.

13 Takashi Sakai, "North Korea's Political System," International Circumstances in the Asia-Pacific Series, Japan Digital Library, Japan Institute of International Affairs, March 2016, https://www.jiia.or.jp/en/pdf/digital_library/korean_peninsula/160331_Takashi_Sakai.pdf.

14 Paul I. Bernstein and Shane Smith, "Through a Glass, a Little Less Darkly: North Korean Nuclear Command and Control in Light of Recent Developments," 38 North, November 14, 2022, <https://www.38north.org/2022/11/through-a-glass-a-little-less-darkly-north-korean-nuclear-command-and-control-in-light-of-recent-developments/>.

15 Anton Sokolin, "Kim Jong Un Oversees Launch of Two New Air Defense Missiles: State Media," NK News, August 24, 2025, <https://www.nknews.org/2025/08/kim-jong-un-oversees-launch-of-two-new-air-defense-missiles-state-media/>.

act if he cannot—illustrates the fundamental tension in North Korea’s NC2: Ensure absolute control, yet guarantee retaliation even if the leader is gone.

MILITARY CHAIN OF COMMAND AND NUCLEAR FORCES ORGANIZATION

Beneath Kim Jong-un, the operational chain of command for nuclear weapons likely runs through a select group of senior military organs. The formal chain would include members of the KPA General Staff Department and Kim’s defense minister, who in theory translate Kim’s orders into military action. However, nuclear use is so politically sensitive that actual command may bypass normal channels. Some evidence suggests that North Korea has created specialized units or offices to handle nuclear warheads and delivery systems.¹⁶ There may also exist a dedicated “Strategic Force” staff (analogous to a nuclear command headquarters) embedded within the military structure, given that North Korea’s strategic rocket forces were elevated to their own branch (the Strategic Force) in 2014. This Strategic Force would oversee ballistic missile units, and by extension would be central to executing nuclear strikes.

North Korea’s nuclear force organization appears to use a dual-key-like system: The missile units belong to the military’s Strategic Force and operate the delivery vehicles (such as missiles and launchers), while a separate authority controls the nuclear warheads until launch time. Missile brigades and their crews conduct regular missile training and tests under Kim’s close guidance, and presumably maintain the launchers and mobile firing units. Meanwhile, the nuclear warheads themselves are kept under custody of a different entity, possibly the Nuclear Weapons Institute or a special munitions bureau. Reports indicate that warheads are stored separately from missiles in secure facilities, guarded by elite units, and are only released to the launch units on direct orders from the supreme leader.¹⁷ This separation of warheads and delivery systems in peacetime is a classic negative-control measure, akin to Soviet practices during much of the Cold War, to prevent unauthorized use. It means that even if a rogue field commander had access to a missile launcher, they could not fire a nuclear weapon without first receiving the actual warhead and activation codes from central authority.

By all indications, North Korea’s military has limited delegated authority over nuclear weapons under normal conditions. Launch units do not physically possess nuclear weapons unless and until the leadership “unlocks” them by mating warheads to missiles. This likely occurs only in high-alert or wartime situations. Such centralized control aligns with Pyongyang’s fear of the military acting independently. In a crisis, however, once Kim did decide to ready his arsenal, the system would transition: Warheads would be distributed to missile units, units would disperse to pre-assigned firing positions, and lower-level commanders might receive conditional orders to launch if certain triggers are met (for instance, loss of communication with leadership or observing specific enemy actions). These dangerous crisis adjustments are explored later. First, it is important to map the physical and technical infrastructure that supports North Korea’s NC2 system.

PHYSICAL INFRASTRUCTURE FOR COMMAND AND CONTROL

Hardened facilities are key features of North Korea’s NC2 infrastructure. The regime has invested heavily in protecting its leadership and ensuring command continuity in the face of superior U.S. and

16 Joseph S. Bermudez Jr., Victor Cha, and Jennifer Jun, “Secret North Korea Missile Base: Sinpung-dong,” *Beyond Parallel*, CSIS, August 20, 2025, <https://beyondparallel.csis.org/undeclared-north-korea-sinpung-dong-missile-operating-base/>.

17 International Crisis Group, *North Korea’s Nuclear and Missile Programs*, Asia Report No. 168 (Washington, DC: U.S. Department of Justice, June 2009), <https://www.justice.gov/file/277576/dl?inline>.

South Korean military capabilities. At the strategic level, Kim Jong-un and his top commanders can relocate to a network of underground command bunkers in wartime. North Korea is honeycombed with underground facilities; there are reportedly major hardened command centers buried deep under mountain ranges in the north, as well as beneath the capital.¹⁸ These bunkers are likely designed to withstand conventional bombardment and possibly certain nuclear strikes. They are likely connected by hardened communications links to military units in the field.¹⁹ During a war, North Korea's leadership could theoretically still transmit orders via secure underground lines, thereby maintaining control over nuclear forces even under enemy attack.

North Korea's ballistic missile units also benefit from an array of smaller hardened sites, including tunneled storage depots and covert transporter garages, which support dispersed operations. For example, the country's medium-range and short-range ballistic missiles are housed at various mountain bases with underground facilities for sheltering launchers. During heightened tension, those launch units can be ordered to sortie from their bases and deploy to pre-surveyed launch locales (e.g., highway turnouts or cleared forest sites). The regime is known to have constructed hidden access portals and camouflaged firing positions for this purpose. Such infrastructure ensures that Pyongyang is not reliant on a single "missile field" or silo complex; instead, the nuclear missile force is geographically distributed and can be shuffled around to complicate adversary targeting. All of this is integral to NC2 because it means Kim can trust that, even if some sites are struck, odds are that some portion of his forces will survive to execute his orders. The emphasis on mobility and underground protection shows how North Korea's NC2 is built for wartime durability.

That said, North Korea's NC2 infrastructure also has notable weaknesses. A glaring one is the communications link to its nascent sea-based deterrent. Pyongyang has tested submarine-launched ballistic missiles (SLBMs) from a coastal submarine, and it is developing a ballistic missile submarine capability.²⁰ However, analysts find no evidence that North Korea possesses the very low frequency (VLF) or other long-range communications systems needed to reliably send launch orders to a submerged nuclear submarine. Unlike the United States or Russia, which operate powerful VLF transmitters and specialized communications for submarines, North Korea appears not to have built such infrastructure.²¹ This means that if a North Korean ballistic missile submarine were on patrol deep at sea, it could become isolated and unable to receive and execute orders. In such an event, a cut-off submarine commander could assume the worst—that Pyongyang had been destroyed—and decide to launch his SLBMs on his own, with no way to verify the situation. This is exactly the kind of hair-raising instability that a fail-deadly NC2 engenders. North Korea may mitigate the risk by keeping any nuclear-armed submarines close to home waters or in port unless war is clearly imminent, but the broader communications gap remains a serious vulnerability in its NC2 architecture.

18 Timothy W. Martin, "North Korea Has a Secret Long-Range Missile Base Near Chinese Border, Report Says," *Wall Street Journal*, August 20, 2025, <https://www.wsj.com/world/asia/north-korea-has-a-secret-long-range-missile-base-near-chinese-border-report-says-6b69d8c0?mod=Searchresults&pos=1&page=1>.

19 "Command and Control," Federation of American Scientists, updated June 15, 2000, <https://nuke.fas.org/guide/dprk/facility/c3i.htm>; and Myeongguk Cheon, *DPRK's NC3 System* (Berkeley, CA: Nautilus Institute for Security and Sustainability, June 2019), <https://nautilus.org/napsnet/napsnet-special-reports/dprks-nc3-system/>.

20 Joseph S. Bermudez Jr., Victor Cha, and Jennifer Jun, "North Korea Launches New Ballistic Missile Submarine." *Beyond Parallel*, CSIS, September 11, 2023, <https://beyondparallel.csis.org/north-korea-launches-new-ballistic-missile-submarine/>.

21 Peter Hayes, *Nuclear Command, Control, and Communications (NC3) in Asia-Pacific* (Berkeley, CA: Nautilus Institute for Security and Sustainability, September 2021), <https://nautilus.org/napsnet/napsnet-special-reports/nuclear-command-control-and-communications-nc3-in-asia-pacific/>.

SAFETY MECHANISMS AND DOCTRINAL CONTROLS

Preventing unauthorized or accidental nuclear detonations is a crucial aspect of NC2. Like all nuclear-possessing states, North Korea faces the classic safety-versus-readiness trade-off. Available evidence suggests its approach to nuclear safety relies more on procedural controls than on high-tech permissive action links (PALs) or automated locks that advanced nuclear states use. In other words, Pyongyang's arsenal is kept "safe" primarily by organizational means: strict human control, separation of components, coded orders, and surveillance of personnel, rather than sophisticated technical capabilities.

As noted, North Korea's default safety mechanism in peacetime is effectively *keeping the guns and ammo separate* until an authorized launch decision is made. Even if a missile unit commander were to go rogue, they would lack the critical pieces to arm a nuclear missile without approval from above. This practice closely parallels the early Chinese and Soviet approach before advanced PAL technology was available: They relied on physical separation and centralized release of warheads to ensure negative control.²² North Korean scientists and military officers reportedly learned basic nuclear weapons-handling doctrine from Soviet advisers in the past, and it appears they likely adopted this model.²³

In terms of technical controls, open sources do not confirm if North Korea has built indigenous PAL devices or coded-electronic locks for its warheads. It is possible that rudimentary codes or disabling switches exist, for example, a required radio code to enable a warhead's detonation sequence. It is more likely that the regime relies on people and process: loyal cadres supervising every step, special authorizing codes transmitted by central command, and perhaps mechanical safing devices that are only removed at the final stage. One could imagine, for instance, that each warhead has a component (like a firing circuit or neutron initiator) that is kept under lock at the warhead storage site and delivered to the launch unit only with Kim Jong-un's explicit order. Without that component, the warhead cannot function. This would be a crude but effective substitute for Western PAL systems. Such measures force deliberate steps and confirmations before a nuclear strike, reducing the chance of an accidental launch due to miscommunication or technical error.

During peacetime, these safety measures would significantly slow North Korea's ability to use nuclear weapons on short notice. Pyongyang appears willing to accept this trade-off of readiness for safety. The regime has a very high bar for releasing nuclear weapons from centralized control during normal circumstances, which means the system is in a "fail-safe" mode by default. This likely contributes to relatively cautious behavior in routine operations. For instance, even as North Korea has conducted hundreds of missile launches during Kim's tenure (some explicitly described as nuclear strike simulations), state media never fails to carefully signal that the supreme leader was present to authorize and guide these exercises.²⁴ There is no indication that field commanders conduct nuclear drills on their own. By contrast, in established nuclear powers like the United States, military

22 Fiona S. Cunningham, "Nuclear Command, Control, and Communications Systems of the People's Republic of China," Tech4GS Special Reports, July 18, 2019, https://securityandtechnology.org/wp-content/uploads/2024/10/fiona_cunningham_IST_report_4-1.pdf.

23 Defense Intelligence Agency, *North Korea Military Power: A Growing Regional and Global Threat* (Washington, DC: U.S. Department of Defense, October 15, 2021), https://www.dia.mil/Portals/110/Documents/News/North_Korea_Military_Power.pdf.

24 Vann H. Van Diepen, "North Korea 'Tactical Nuke' Drill: Claims on Command/Control and Hints of a First-Ever Silo Launch," 38 North, March 29, 2023, <https://www.38north.org/2023/03/north-korea-tactical-nuke-drill-claims-on-command-control-and-hints-of-a-first-ever-silo-launch/>.

exercises regularly rehearse nuclear release with delegated authority in simulated communications disruption scenarios, something North Korea has not publicly shown. The message from Pyongyang is that Kim remains in charge at all times, until he decides otherwise.

Of course, the flip side is that once Kim does decide to enable use, many safety locks are likely removed. North Korea's system could then become "ultra-permissive" under certain conditions. This dual nature—tight control in peacetime, rapid shift to loosened control in crisis—is what makes the system truly dangerous by design. In aggregate, North Korea's NC2 safety approach is likely more organizational than technological. The regime prevents unwanted use through the iron discipline of its totalitarian structure, but if it chooses to employ nuclear weapons, it likely strips away many normal safety measures to allow quick action. This means that, at the moment of greatest danger, North Korea's nuclear weapons may be in their least inhibited state.

PEACETIME CONTROLS VERSUS CRISIS ADJUSTMENTS

PEACETIME POSTURE: CENTRALIZED ASSERTIVE CONTROL

In day-to-day operations, Pyongyang's overriding priority is to prevent any unauthorized or accidental nuclear use. Thus, peacetime NC2 is characterized by hypercentralization, some form of physical control measures, and low readiness. North Korea appears willing to accept a relatively slow nuclear response time in peacetime in exchange for tight negative control. Warheads are stored unmated or in separate locations from missiles; launch units do not have nuclear munitions on hand; and the entire system likely requires Kim Jong-un's explicit approval at multiple stages. This means that if a crisis erupted suddenly, North Korea's baseline posture is "fail-safe," and absent direct orders from the supreme leader, nuclear weapons would not be immediately usable.

Evidence of this peacetime restraint can be seen in how North Korea conducts missile tests and exercises. Even as Pyongyang has begun describing certain units as "tactical nuclear operation units" and has practiced missile launches simulating nuclear strikes, state media is careful to note that Kim personally supervises and approves these drills. There are no public signs of delegated nuclear release authority in training. The consistent message is that Kim guides everything.

Additionally, North Korea's missile tests use deliberate procedures that hint at centralized control. For example, in several intercontinental ballistic missile test launches, the missiles were first seen on their transporter erector launchers (TELs) but then erected and fired from a separate "test stand" rather than directly from the vehicle. Analysts interpret this as a safety measure to avoid damaging the regime's limited inventory of TEL vehicles, but it may also be a sign of how the regime approaches nuclear operations in a peacetime environment. In short, during peacetime or day-to-day alert levels, North Korea's NC2 is highly assertive and leader-centric, prioritizing prevention of any unsanctioned use over immediate launch readiness.

CRISIS AND WARTIME POSTURE: DELEGATIVE "FAIL-DEADLY" TILT

As a serious crisis develops or war becomes imminent, North Korea's posture is expected to shift dramatically toward ensuring weapons can be used rapidly if ordered. The regime would likely move from a pure fail-safe orientation to a hybrid or fail-deadly orientation as threat levels peak. This transition would involve preparing the arsenal for possible use and eventually partially delegating launch authority in advance of impending conflict.

Multiple steps would mark this shift. First, Kim Jong-un would order the mating of warheads to delivery systems, arming the force. Warheads would be transported from storage and installed on missiles or handed over to the missile units. North Korean official commentary has alluded to raising the alert posture of nuclear forces in steps where Kim can declare different readiness levels. For example, Pyongyang has referenced the completion of preparations when deterrence is judged to be failing.²⁵ This could refer to dispersing missiles and mating warheads. Once mated, the weapons are field-deployed and can potentially be launched on short notice.

Second, Kim would disperse and delegate. Missile units would deploy from their peacetime garrisons to predesignated firing positions around the country. They would then receive standing orders or conditional predelegation for nuclear release. One credible scenario is a two-tiered command system, where the upper tier (Kim and the High Command in secure bunkers) will try to maintain direct control as long as possible, but the lower tier (field units such as missile brigades and even submarine captains) would have clear “if cut off, then fire” orders. North Korea’s 2022 nuclear law essentially establishes this: If the central command is in danger or unable to function, predetermined plans kick in for automatic nuclear retaliation.²⁶ In practice, this could mean that once hostilities begin and bombs start falling on North Korea, Kim’s tolerance for centralized inhibition evaporates and the priority shifts to ensuring a nuclear strike can happen under any circumstance, even without final human confirmation.

Under these conditions, North Korean missile commanders may be told in advance something to the effect of: “If you lose contact with headquarters and observe certain triggers (e.g., massive strikes on leadership sites), you are authorized to launch.” This kind of conditional delegation creates a hair-trigger posture. A salient fear is that a North Korean field commander, cut off and under attack, might launch on what he perceives as signs of decapitation, even if in reality some communication channels remain intact and functional.

North Korea might take steps to mitigate the most extreme risks of predelegation. For instance, it could keep certain assets like ballistic missile submarines in port or very close to home during a crisis, so that communication is more reliable and the chance of an isolated launch is lower. It could also set up “shadow” chains of command by designating a senior official or military commander as a backup to authorize nuclear use if Kim is out of action, essentially a line of succession for nuclear release. Indeed, the 2022 law hints that if Kim is killed, another official may be empowered to order strikes.²⁷ Furthermore, Pyongyang may have rudimentary broadcast methods to send a general “fire” signal to all units if normal command networks break down. For example, this could take the form of a special code transmitted over military radio or even via state media that frontline units recognize as the cue to launch. However, any such method is a double-edged sword: It ensures retaliation occurs, but at the cost of control and precision. Historically, even Soviet leaders implemented only very limited predelegation and always tried to maintain some human fail-safe.²⁸ North Korea’s extremely personalist regime would likewise be loath to delegate actual launch authority too broadly. Even in crisis, Kim would likely keep

25 Kelsey Davenport, “North Korea Conducts Nuclear Strike Drill,” Arms Control Today, June 2025, <https://www.armscontrol.org/act/2025-06/news/north-korea-conducts-nuclear-strike-drill>.

26 Korea Central News Agency, “Law on DPRK’s Policy on Nuclear Forces Promulgated,” KCNA Watch, September 9, 2022, <https://kcnawatch.org/newstream/1662687258-950776986/law-on-dprks-policy-on-nuclear-forces-promulgated/>.

27 Ibid.

28 Beyza Ünal and Julia Cournoyer, *Uncertainty and Complexity in Nuclear Decision-Making: Nuclear Decision-Making Case Studies* (London: Chatham House, March 2022), <https://www.chathamhouse.org/2022/03/uncertainty-and-complexity-nuclear-decision-making/05-nuclear-decision-making-case-studies>.

the circle of those empowered to initiate a launch as tight as possible (perhaps just one trusted general or a handful of unit commanders given a conditional green light). Nonetheless, once war is underway, it may be impossible to prevent individual commanders from acting on standing orders. The moment Kim activates an automatic retaliation stance, he has essentially uncorked the genie. Events could move forward without further input from him.

This shift from peacetime restraint to wartime permissiveness is precisely what makes crisis stability with North Korea so fraught. The regime's imperative to guarantee nuclear retaliation means that as a conflict escalates, it will deliberately streamline its NC2, removing layers of safety to ensure weapons can be fired at the very time when false alarms or misunderstandings are likely. In other words, North Korea's nuclear forces go from fully locked in peacetime to potentially "fire at will" under certain crisis conditions. Such a posture is inherently destabilizing because it compresses the decision times for all sides and creates enormous pressure to act (or preempt) before losing the chance. For North Korea, the danger is that by adopting a hair-trigger stance under pressure, it increases the probability of a nuclear launch based on erroneous indicators or rogue initiative. For the United States and South Korea, the challenge is how to deter or defeat North Korea without triggering that automatic doomsday mechanism.

TEMPORAL DYNAMICS AND OPERATIONAL LATENCY

Time plays a consequential role in North Korea's NC2 system. The likely separation of warheads from delivery systems means that a decision to use nuclear weapons would not translate into immediate action. Moving warheads from storage, mating them to missiles, conducting safety and readiness checks, and transmitting coded launch orders would likely take many hours—and possibly up to a full day or longer. Older analyses have estimated that this process could take one to two days under certain conditions.²⁹ Still, that broad timeframe remains plausible given what is known about the country's limited handling equipment, constrained logistics, and preference for centralized oversight at every stage. In peacetime, this deliberate tempo functions as a safety feature in that it reduces the likelihood of accidental or unauthorized launch by forcing multiple procedural steps and ensuring that Kim Jong-un's approval is physically required at several points.

Yet not all delivery systems are equal, nor would they necessarily share the same readiness posture. It is possible that certain weapons systems are maintained with warheads already mated, or that their associated warheads are held in a higher state of readiness compared to other systems, meaning the arming and launch-preparation clock could begin at a shorter baseline for missile systems deemed the most vulnerable or valuable.³⁰ Likewise, how assets are deployed will influence how quickly each missile type can be brought online.

In a crisis, operational lag could become a liability. Once Kim authorizes the transfer and mating of warheads, the entire NC2 cycle would accelerate from hours or days of preparation to potentially minutes once missiles are armed, dispersed, and pre-delegated for launch. If certain storage and assembly sites are collocated with missile units—as appears likely near some production hubs—transfer times may shorten, but that convenience also increases vulnerability to prompt attack. A leadership that perceives those nodes to be in danger could feel pressure to move faster, compress timeframes, and

29 International Crisis Group, *North Korea's Nuclear and Missile Programs*.

30 Open Nuclear Network, *North Korean Short-Range Systems* (Vienna: Open Nuclear Network, January 2023), <https://opennuclear.org/sites/default/files/2023-01/Report-NORTH-KOREAN-SHORT-RANGE-SYSTEMS%20%281%29.pdf>.

delegate authority to field units in ways that sharply reduce human oversight. As command timelines shrink, each stage of the process becomes more exposed to error, misinterpretation, or loss of control, and the logic of “use it or lose it” begins to dominate over restraint.³¹

STRATEGIC IMPLICATIONS FOR DETERRENCE AND CRISIS STABILITY

North Korea’s NC2 system, as outlined above, carries profound implications for deterrence and crisis stability in Northeast Asia. Its unique blend of extreme centralized control and planned delegation in extreme circumstances pose a complex deterrence problem. On the one hand, Pyongyang’s tight peacetime control and demonstrated rationality in nonwar conditions suggest Kim Jong-un is deterrable under normal circumstances and is unlikely to launch nuclear weapons unless he truly perceives an existential threat. On the other hand, the moment Kim does feel such a threat, his NC2 would shift to a mode where nuclear weapons could fly with minimal further deliberation. This creates a razor’s edge in any high-stakes confrontation.

DETERRENCE AND CREDIBILITY

North Korea’s fail-deadly provisions are intended to strengthen deterrence by convincing adversaries that it will retaliate no matter what. By signaling that nuclear strikes will be automatic if Kim is attacked, Pyongyang is trying to deter decapitation strikes and large-scale conventional attacks. From a strict deterrence perspective, this strategy is logical because it forces the U.S.-South Korea alliance to consider that even a successful first strike eliminating Kim could result in nuclear launch by surviving forces. Thus, it raises the costs and risks of any attempt to preempt or invade. The credibility of North Korea’s deterrent is arguably enhanced by this doomsday setup. In practice, this may restrain the United States and South Korea from seriously contemplating decapitation operations except in the most extreme scenarios. Indeed, U.S. and South Korean officials publicly emphasize that they do not seek regime change by force, partly to avoid cornering Pyongyang into a use-it-or-lose-it mindset.³²

However, the credibility gained in deterrence also comes with increased danger of inadvertent use. A fail-deadly system is convincing as a threat precisely because it takes human judgment out of the final step. But removing human judgment means a higher chance of misinterpretation or technical error leading to launch. For example, if conventional strikes or “left-of-launch” operations sever Kim’s communications in a conflict, North Korean commanders might wrongly assume Kim has been killed and execute predelegated launch orders, unleashing nuclear war based on a false signal.³³ This is not a far-fetched scenario; it is the nightmare that kept Cold War planners up at night on both sides.³⁴ Thus, while North Korea’s automatic retaliation posture may strengthen deterrence by making its threats more credible, it simultaneously undermines crisis stability by making actual nuclear use—whether intentional or not—more likely in a fast-moving situation.

31 Even Hellan Larsen, “Deliberate Nuclear First Use in an Era of Asymmetry,” *Journal of Conflict Resolution* 68, no. 5 (2024): 849–74, <https://doi.org/10.1177/00220027231185154>.

32 Emma Chanlett-Avery and Mark E. Manyin, “U.S.–North Korea Relations,” Congressional Research Service, IF10246, updated November 29, 2017, https://www.congress.gov/crs_external_products/IF/PDF/IF10246/IF10246.11.pdf.

33 Left-of-launch operations target an adversary’s weapons systems before they are fired—hence, “left” of the launch point on a timeline of an attack. In nuclear strategy, this concept refers to preemptive measures such as cyber intrusions or electronic warfare designed to disrupt missile command, control, and launch processes. These operations might aim to corrupt targeting data, disable guidance systems, or interfere with communications links. The idea is to neutralize a threat without kinetic strikes.

34 William Burr and Jeffrey Kimball, “Nuclear Threats and Alerts: Looking at the Cold War Background,” *Arms Control Today*, April 2022, <https://www.armscontrol.org/act/2022-04/features/nuclear-threats-and-alerts-looking-cold-war-background>.

ESCALATION CONTROL AND RISKS OF MISCALCULATION

In a conventional conflict on the Korean Peninsula, time and communication would be critical to preventing escalation to the nuclear level. North Korea's NC2 structure severely compresses that timeline. Once Kim believes a nuclear strike might be required, he is likely to issue advance use authority and go to launch-ready status. At that point, any further escalation or perceived decapitating efforts could immediately trigger nuclear launch. This creates a "use-it-or-lose-it" scenario for North Korean forces and "strike or be struck" for the adversary.

For the United States and South Korea, one implication is that attempts to eliminate North Korea's nuclear capability (through left-of-launch strikes or leadership targeting) could backfire catastrophically. An attempted decapitation or disarming strike might actually provoke the very nuclear launch it sought to prevent if Pyongyang's automated or predelegated systems activate in response. This puts a premium on avoiding miscalculation in a crisis. Clear signaling and communication would be needed to convince Kim that he is not facing imminent personal destruction in order to dissuade him from enabling the fail-deadly mode too early. Conversely, if Kim has already set his system to launch automatically, U.S. and South Korean planners face a grave dilemma: Striking certain targets like communication nodes or specific units could directly cause a nuclear response if those units interpret the strike as the signal to fire. In essence, once North Korea's nukes are decentralized, the escalation ladder has extremely few rungs and could skip straight to nuclear use.

This dynamic greatly complicates allied military planning. Strategies such as South Korea's "Kill Chain" concept for preemptive strikes on North Korean missiles become far more risky if North Korea's NC2 is automated.³⁵ South Korea's defense plans do include options to preempt imminent nuclear launches and to eliminate North Korea's leadership in extreme scenarios as part of the Korea Massive Punishment and Retaliation plan.³⁶ But if North Korea's system is set to retaliate even without a functioning leadership, those plans could trigger exactly what they aim to prevent.

ALLIED DETERRENCE AND DEFENSE POSTURES

For the United States and South Korea, adapting to this reality is challenging but necessary. It will require a two-pronged approach: the ability to deter deliberate North Korean nuclear use, paired with measures to reduce the risk of accidental or unauthorized launches in a crisis. On the deterrence front, the United States has been reinforcing its extended nuclear deterrent commitments to South Korea through military exercises, strategic asset deployments, and high-level declaratory policy to ensure Kim Jong-un understands that any nuclear attack on the allies will result in an overwhelming response. Kim must believe that using nuclear weapons, even automatically, would seal his regime's fate. Maintaining that deterrent credibility is crucial to dissuade any North Korean notion that early use could be a winning strategy.

At the same time, the allies need to invest in crisis management tools. This could include improving hotlines or indirect communication channels to Pyongyang that might be used in a crisis to clarify intentions or negotiate a stand-down. It might also involve exploring risk reduction measures—however difficult this may be with a state as recalcitrant as North Korea—to put some guardrails on

35 Jihoon Yu, "Rethinking South Korea's Three-Axis System: Toward a More Balanced and Resilient Deterrence Architecture," RealClearDefense, May 12, 2025, https://www.realcleardefense.com/articles/2025/05/12/rethinking_south_koreas_three-axis_system_1109579.html.

36 Ibid.

this inherently unstable deterrence relationship. This could include pursuing limited agreements, such as mutual pledges not to target leadership bunkers or not to interfere with C2 communications during peacetime, to reduce the likelihood of panic and predelegation if a crisis erupts.³⁷ Even small confidence-building steps, if verifiable, could lower the temperature. Another idea floated is for the United States and South Korea to adjust certain exercises or operational plans that Pyongyang finds most provocative in exchange for North Korea being more transparent about its command arrangements or refraining from full automation.³⁸ Such trade-offs would be controversial, but the goal would be to give Kim less incentive to set his system on a hair-trigger. Essentially, the allies may seek ways to assure North Korea that Kim's survival can be negotiated if he refrains from crossing the nuclear threshold. This would be an assurance aimed at keeping him from predelegating a launch the moment conflict seems imminent.

In any case, the presence of an automatic or delegated launch capability in North Korea's hands means the margin for error in a future crisis on the Korean Peninsula is distressingly thin. All sides—Pyongyang, Seoul, and Washington—would have to navigate with extreme care. The United States and its allies will need to refine their deterrence posture to be firm yet flexible, emphasizing both strength and open lines of communication. Alliance decisionmakers must be psychologically prepared for a scenario in which any significant military strike on North Korea could trigger nuclear reprisal. That does not mean tolerating nuclear blackmail; it means preparing to manage a showdown where misreading North Korea's NC2 system and processes could be catastrophic.

CONCLUSION

North Korea's NC2 system is, in many respects, dangerous by design. It is configured to maximize the regime's chances of striking back if attacked, but in doing so it creates hair-trigger dynamics and serious escalation risks. On the positive side for Pyongyang, this NC2 design likely bolsters the credibility of its deterrent in that adversaries know that even a successful decapitation strike or first strike might not prevent North Korean nuclear retaliation. On the negative side, the very steps taken to ensure retaliation—extreme centralization suddenly giving way to rapid delegation, limited communications that become vulnerable under fire, and automated response provisions—make it more likely that a crisis could spiral out of control with nuclear use that no one truly intended.

For the United States and its allies, grappling with North Korea's NC2 is essential to maintaining stability on the Korean Peninsula. It underlines that pursuing decapitation strategies or expecting a neat victory over North Korea would be extraordinarily perilous. Deterrence must be approached with clarity and caution, and any military confrontation with Pyongyang will demand deft crisis and alliance management, backed by reliable communication channels and mutual restraint measures. Misreading or misplaying the NC2 situation could bring about the very nuclear catastrophe that deterrence is supposed to prevent. In the end, keeping the peace in Northeast Asia will depend on understanding the nuances and dangerous logic of North Korea's NC2 system.

37 Ankit Panda, "How to Reduce Nuclear Risks Between the United States and North Korea," United States Institute of Peace, February 5, 2024, <https://www.usip.org/publications/2024/02/how-reduce-nuclear-risks-between-united-states-and-north-korea>.

38 Shawn Rostker, "The Korean Peninsula Has Seen Grand Overtures Come and Go – What Matters Now Is Whether Small Steps Can Still Lead Somewhere," 38 North, July 9, 2025, <https://www.38north.org/2025/07/the-korean-peninsula-has-seen-grand-overtures-come-and-go-what-matters-now-is-whether-small-steps-can-still-lead-somewhere/>.

Crisis Management and Strategic Stability



Balancing Lethality and Restraint

How Targeting Matters for Escalation Management

By Frank Kuhn¹

INTRODUCTION

Due to the deteriorating international security environment, the likelihood that the United States will find itself involved in a military conflict with another nuclear power in the coming years has increased substantially. As the Office of the Director of National Intelligence concluded in the U.S. intelligence community's 2025 threat assessment, "Russia views its ongoing war in Ukraine as a proxy conflict with the West, and its objective to restore Russian strength and security in its near abroad against perceived U.S. and Western encroachment has increased the risks of unintended escalation between Russia and NATO."² Meanwhile, China is laying the necessary military and legal groundwork for a potential invasion of Taiwan.³ According to Mike Studeman, the former commander of the Office for Naval Intelligence, "Xi [Jinping]'s most critical choices reflect a march to war."⁴ Finally, some North Korea experts have raised concerns that Kim Jong-un may have made the decision to go to war, although they assess that it remains unclear when and how.⁵

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- 1 Frank Kuhn is a doctoral researcher at the Peace Research Institute Frankfurt (PRIF) in Germany. The views expressed in this paper represent those of the author alone.
 - 2 United States Intelligence Community, *Annual Threat Assessment of the U.S. Intelligence Community* (McLean, VA: Office of the Director of National Intelligence 2025), 16, <https://www.dni.gov/files/ODNI/documents/assessments/ATA-2025-Unclassified-Report.pdf>.
 - 3 Ibid., 11; Cheng Deng Feng and Tim Boyle, "Exposing China's Legal Preparations for a Taiwan Invasion," *War on the Rocks*, March 11, 2025, <https://warontherocks.com/2025/03/exposing-chinas-legal-preparations-for-a-taiwan-invasion/>.
 - 4 Mike Studeman, "China is Battening Down for the Gathering Storm over Taiwan," *War on the Rocks*, April 17, 2024, <https://warontherocks.com/2024/04/china-is-battening-down-for-the-gathering-storm-over-taiwan/>.
 - 5 Robert L. Carlin and Siegfried S. Hecker, "Is Kim Jong Un Preparing for War?," *38 North*, January 11, 2024, <https://www.38north.org/2024/01/is-kim-jong-un-preparing-for-war/>.

The growing likelihood of military conflict between the United States and one or more of its nuclear-armed adversaries has brought renewed attention to the issue of escalation management in nonnuclear conflict.⁶ Effective escalation management is particularly difficult because it needs to account for the conflicting political pressures that would likely be present during a war between two nuclear powers. While averting nuclear first use by a U.S. adversary would be an important political objective, a commander-in-chief may still feel compelled to authorize potentially escalatory military operations if this would improve the chances of winning a war. Nevertheless, any decision to cross an escalatory threshold should be a deliberate choice to ensure that escalation is managed.⁷

This paper examines how the U.S. Department of Defense (DOD) could use existing elements of the joint targeting cycle to reduce the risk of unintentional nuclear escalation. It focuses on the Sensitive Target Approval and Review process, the Collateral Damage Estimation Methodology, and the No-Strike and Restricted Target List. Drawing on the extensive scholarly literature dealing with nuclear escalation risks in conventional military conflict, it recommends that the DOD should study how expanding sensitive target criteria, (re-)prioritizing the mitigation of civilian harm, and restricting attacks on an adversary's homeland and dual-capable assets to nonlethal or non-kinetic means could help manage escalation. The paper assumes that target selection is the key variable under U.S. control for managing escalation and that the United States will not employ nuclear weapons first in a conventional conflict.⁸ It is concerned solely with preventing a conflict from crossing the nuclear threshold, not with managing escalation after nuclear employment.

The remainder of this paper is structured as follows: The first section outlines the three mechanisms of escalation and approaches to manage them. The second identifies likely escalatory thresholds in a conflict between the United States and a nuclear-armed adversary. The third examines key elements of the joint targeting process and how they could help manage unintentional escalation. The final section summarizes the overall argument.

ESCALATION MECHANISMS AND ESCALATION MANAGEMENT

There are three escalation mechanisms that would likely be relevant in a conventional military conflict between the United States and a nuclear-armed adversary: deliberate escalation, inadvertent escalation, and accidental escalation.

Deliberate escalation occurs when an actor intentionally crosses an escalatory threshold in a conflict. While the exact enemy response may be uncertain, the actor anticipates that the action will be perceived as escalatory and likely provoke a reaction. In other words, escalation is chosen because the expected benefits outweigh the costs or because it may increase the chances of winning the conflict.⁹ One example of deliberate escalation is Japan's decision to attack Pearl Harbor on December 7, 1941. Aware of its slim chances of victory, the Japanese leadership nonetheless chose war over the alternative: economic collapse under the pressure of the U.S. oil embargo.¹⁰

6 For a recent example, see Dahlia Anne Goldfeld et al., *Denial Without Disaster—Keeping a U.S.-China Conflict Over Taiwan Under the Nuclear Threshold: Vol. 1, An Overview of Ideas for U.S. Conventional Joint Long-Range Strike in Support of Escalation Management* (Santa Monica, CA: RAND Corporation, 2024), https://www.rand.org/pubs/research_reports/RRA2312-1.html.

7 Forrest E. Morgan et al., *Dangerous Thresholds: Managing Escalation in the 21st Century* (Santa Monica, CA: RAND Corporation, 2008), 163–64, <https://www.rand.org/pubs/monographs/MG614.html>.

8 Goldfeld et al., *Denial Without Disaster*, 29.

9 Morgan et al., *Dangerous Thresholds*, 20–23.

10 Scott D. Sagan, "The Origins of the Pacific War," *Journal of Interdisciplinary History* 18, no. 4 (Spring 1988): 893–922, <https://doi.org/10.2307/204828>.

Inadvertent escalation occurs when one side's deliberate actions unintentionally provoke a stronger enemy response, typically by crossing "a threshold of intensity or scope" that is critical to the adversary but was overlooked or underestimated by the actor.¹¹ For example, as Barry Posen argued in his seminal 1982 article, "Inadvertent Nuclear War? Escalation and NATO's Northern Flank," intense NATO conventional operations on the alliance's northern flank might have threatened the survivability of Soviet strategic nuclear forces, prompting nuclear escalation even if that was not NATO's intent.¹²

Accidental escalation is also unintended, not due to the unforeseen effects of deliberate actions but to events that were never planned in the first place.¹³ One such accident occurred during Operation Allied Force in 1999, when the U.S. Air Force bombed the Chinese embassy in Belgrade after a targeting mishap, resulting in diplomatic turmoil between the two countries.¹⁴ Accidental escalation can also result from military actions that are not authorized or intended by national leadership, either due to unclear guidance or failure to follow orders.¹⁵ Such risks were evident during the Cold War, when the Joint Strategic Target Planning Staff (JSTPS) repeatedly ignored presidential guidance in nuclear planning until civilian oversight corrected this practice in the late 1980s.¹⁶

While the risk of deliberate enemy escalation can be managed using deterrence, mitigating the risk of inadvertent and accidental escalation requires careful escalation management and force management.¹⁷ Managing inadvertent escalation begins with identifying adversary escalatory thresholds through intelligence collection and analysis. This can be difficult, as thresholds may be unclear before hostilities or could shift during conflict. Once potential thresholds are understood, policymakers can make informed choices. They can either avoid them to reduce the risk of inadvertent escalation or deliberately challenge them if the potential benefits are seen to outweigh the risks. In either case, escalation becomes a deliberate policy decision rather than an unintended outcome.¹⁸ Accidental escalation, by contrast, cannot be entirely avoided due to the unpredictable nature of pure accidents. Nevertheless, national leadership can reduce its likelihood through force management measures, including clear rules of engagement, rigorous training, and robust command and control during operations.¹⁹

POTENTIAL ESCALATORY THRESHOLDS IN MILITARY CONFLICT

Although escalatory thresholds are not always identifiable in advance, may differ by adversary, and can shift during a conflict, it is possible to identify plausible thresholds in conventional military operations that, if crossed, could prompt nuclear escalation. These fall into three categories: *geographical thresholds* (the scope or location of actions, including operations in areas an adversary views as strategic sanctuaries); *target-specific thresholds* (particularly sensitive or high-value targets, including nuclear forces); and *tempo-of-operations thresholds* (the speed, scale, and intensity of attacks or force movements).²⁰

11 Morgan et al., *Dangerous Thresholds*, 28.

12 Barry R. Posen, "Inadvertent Nuclear War? Escalation and NATO's Northern Flank," *International Security* 7, no. 2 (Fall 1982): 28–54, <https://www.jstor.org/stable/2538432>.

13 Morgan et al., *Dangerous Thresholds*, 26–28.

14 Michael Russell Rip and James M. Hasik, *The Precision Revolution: GPS and the Future of Aerial Warfare* (Annapolis, MD: Naval Institute Press, 2002), 389–99.

15 Morgan et al., *Dangerous Thresholds*, 26–28.

16 Franklin C. Miller, "Establishing the Ground Rules for Civilian Oversight," in *Managing U.S. Nuclear Operations in the 21st Century*, ed. Charles L. Glaser et al. (Washington, DC: Brookings Institution Press, 2022).

17 Morgan et al., *Dangerous Thresholds*, 160–65.

18 *Ibid.*, xiii–xiv, 163–65.

19 *Ibid.*, 165.

20 These categories are not intended to be exhaustive. Rather, they reflect the most likely escalatory thresholds identified

These categories are not mutually exclusive, as a single action can cross multiple thresholds, such as a bolt-from-the-blue strike against an adversary's nuclear forces deep within its territory. Crossing a threshold does not guarantee nuclear escalation; this depends on the adversary's calculus. But the risk grows as more thresholds are crossed, especially amid uncertainty or existential threat.

GEOGRAPHICAL THRESHOLDS

Perhaps the most straightforward escalatory threshold that may prompt nuclear escalation by an adversary during conventional military conflict is a U.S. strike on the adversary's homeland. As Herman Kahn has noted, states usually distinguish between areas that are considered their homeland and others that are not: "Indeed, the line between the external world and the nation may even be stronger as a firebreak than the threshold between conventional and nuclear war, since it is an older distinction, invested with far more emotion and prestige."²¹

In the context of a potential war between the United States and China, several research reports and scholarly articles—including one wargame conducted by CSIS—suggest that strikes against the Chinese mainland "create grave risks of escalation."²² Similarly, a November 2024 research report from RAND concluded that such an action "represents an important escalation threshold."²³ Russia also amended its nuclear doctrine in 2024 to include the "massive launch" and crossing of "air and space attack weapons" such as cruise missiles into Russian state territory as a condition for the employment of nuclear weapons.²⁴ While this doctrine constitutes declaratory policy and may not necessarily reflect the actual conditions under which nuclear weapons would be employed, Barry Posen assessed during the Cold War that air strikes against the Soviet Union's "Motherland" could "trigger an emotional response from Soviet leaders, even if they did not do much real military damage."²⁵

Many U.S. decisionmakers also believe that strikes against an adversary's homeland are an important escalatory threshold. Multimethod research seems to suggest that the existence of Chinese nuclear weapons reduces the likelihood of U.S. conventional strikes against mainland China.²⁶ In a wargame played in the National Security Council during the Obama administration, the Principals Committee responded to limited Russian nuclear first use in a Baltic contingency by carrying out several nuclear strikes against the former Soviet republic of Belarus because nuclear strikes on Russian territory were considered too escalatory.²⁷ Finally, the Biden administration exercised considerable caution in supporting Ukraine after Russia's full-scale invasion in February 2022.²⁸ In an opinion piece published

in the scholarly literature and informed by historical cases of military conflict. For a more comprehensive overview, see Goldfeld et al., *Denial Without Disaster*, 18–25.

21 Herman Kahn, *On Escalation: Metaphors and Scenarios*, 2nd ed. (New York: Routledge, 2017), 142–43, <https://doi.org/10.4324/9781315125565>.

22 Mark F. Cancian, Matthew Cancian, and Eric Heginbotham, *The First Battle of the New War: Wargaming a Chinese Invasion of Taiwan* (Washington, DC: CSIS, 2023), 122, <https://www.csis.org/analysis/first-battle-next-war-wargaming-chinese-invasion-taiwan>.

23 Goldfeld et al., *Denial Without Disaster*, 29.

24 Simon Saradzhyan, "New Principles of Russia's Nuclear Deterrence Liberalize Conditions for Use, Unsurprisingly," Harvard Kennedy School, Russia Matters Project, November 19, 2024, <https://www.russiamatters.org/blog/new-principles-russias-nuclear-deterrence-liberalize-conditions-use-unsurprisingly>.

25 Posen, "Inadvertent Nuclear War."

26 John Speed Meyers, "Mainland Strikes and U.S. Military Strategy Towards China: Historical Cases, Interviews, and a Scenario-Based Survey of American National Security Elites" (Santa Monica, CA: Pardee RAND Graduate School, 2019), <https://doi.org/10.7249/RGSD430>.

27 Fred M. Kaplan, *The Bomb: Presidents, Generals, and the Secret History of Nuclear War* (New York: Simon & Schuster, 2020), 254–58.

28 Janice Gross Stein, "Escalation Management in Ukraine: 'Learning by Doing' in Response to the 'Threat That Leaves Something to Chance,'" *Texas National Security Review* 6, no. 3 (Summer 2023): 29–50, <https://doi.org/10.26153/TSW/47414>.

in the *New York Times*, President Joe Biden declared that the U.S. government is “not encouraging or enabling Ukraine to strike beyond its borders.”²⁹ In line with this policy, the United States did not supply the shorter-range version of the MGM-140 Army Tactical Missile System (ATACMS) until October 2023 and waited another six months, until March 2024, before it provided Ukraine with the longer-range version of the missile.³⁰ It also did not authorize Ukraine to strike Russian territory with U.S. weapons until 2024.³¹

A potentially significant subset of homeland targets could involve areas in or near the capital, as well as politically, economically, and culturally important sites with substantial symbolic value to the adversary. This is because military operations against the capital may generate perceptions of an imminent decapitation strike, a strategic function long-range strike weapons are well suited to fulfill.³² Strikes against politically, economically, and culturally significant sites—particularly those elevated by nationalism or ideological narratives—may also be perceived by the adversary as acts of deliberate humiliation, increasing the risk of an escalatory response.³³

TARGET-SPECIFIC THRESHOLDS

In addition to strikes against the enemy’s homeland, there are particularly sensitive sets of targets that could lead to nuclear escalation if attacked or destroyed: an adversary’s nuclear forces; dual-capable assets, including command, control, communications, computers, cyber, intelligence, surveillance and reconnaissance (C5ISR) capabilities; and civilian or dual-use infrastructure. These are treated as a distinct category of thresholds because they are not always located on enemy territory, and their targeting entails greater escalatory risks than strikes against general military targets within an enemy’s homeland.

The first and perhaps most obvious escalatory threshold in this category is attacks against elements of an enemy’s nuclear forces. In such a scenario, an adversary may interpret U.S. nonnuclear precision strikes as an attempt to neutralize its nuclear second-strike capabilities and choose to escalate rather than risk the destruction or degradation of its nuclear arsenal.³⁴ This situation is commonly characterized as the “use-them-or-lose-them” dilemma and is considered particularly acute in a conflict against states with smaller, emerging nuclear arsenals.³⁵ Additionally, both Russia and China

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- 29 Joseph R. Biden, “President Biden: What America Will and Will Not Do in Ukraine,” *New York Times*, May 31, 2022, <https://www.nytimes.com/2022/05/31/opinion/biden-ukraine-strategy.html>.
- 30 David E. Sanger et al., “Ukraine Uses Powerful American-Supplied Missiles for First Time,” *New York Times*, October 17, 2023, <https://www.nytimes.com/2023/10/17/world/europe/ukraine-atacms-attacks-russia.html>; and Helene Cooper, “Ukraine Could Use New Weapons to Hit Russian Targets in Crimea, Pentagon Says,” *New York Times*, April 25, 2024, <https://www.nytimes.com/2024/04/25/us/politics/ukraine-aid-atacms.html>.
- 31 Adam Entous et al., “Biden Allows Ukraine to Strike Russia with Long-Range U.S. Missiles,” *New York Times*, November 17, 2024, <https://www.nytimes.com/2024/11/17/us/politics/biden-ukraine-russia-atacms-missiles.html>.
- 32 Fabian R. Hoffmann, “The Strategic-Level Effects of Long-Range Strike Weapons: A Framework for Analysis,” *Journal of Strategic Studies* 47, nos. 6–7 (December 2024): 964–1000, <https://doi.org/10.1080/01402390.2024.2351500>. On decapitation strikes as a potential pathway to nuclear escalation, see Goldfeld et al., *Denial Without Disaster*, 15.
- 33 Joshua Rovner, “Two Kinds of Catastrophe: Nuclear Escalation and Protracted War in Asia,” *Journal of Strategic Studies* 40, no. 5 (2017): 696–730, <https://doi.org/10.1080/01402390.2017.1293532>.
- 34 Posen, “Inadvertent Nuclear War”; 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, https://doi.org/10.1162/ISEC_a_00274.
- 35 Peter D. Feaver, “Command and Control in Emerging Nuclear Nations,” *International Security* 17, no. 3 (Winter 1992): 160–87, <https://doi.org/10.2307/2539133>. On the “use-them-or-lose-them” dilemma in the context of non-nuclear military operations, see Wu Riqiang, “Assessing China-U.S. Inadvertent Nuclear Escalation,” *International Security* 46, no. 3 (Winter 2021): 128–62, https://doi.org/10.1162/isec_a_00428; Ian Bowers and Henrik Stålhane Hiim, “Conventional Counterforce Dilemmas: South Korea’s Deterrence Strategy and Stability on the Korean Peninsula,” *International Security* 45, no. 3 (Winter 2020): 7–39, https://doi.org/10.1162/isec_a_00399; and Rovner, “Two Kinds of Catastrophe.”

have expressed concerns that the United States could use its advanced conventional long-range strike weapons against their nuclear arsenals, also known as conventional counterforce.³⁶

Whether the U.S. military would target an adversary's second-strike capabilities in conventional conflict is unclear from unclassified sources. Statements from various U.S. Navy spokespersons during the Cold War suggest that any Soviet vessels, including ballistic missile submarines, would have been high-priority targets even in a conventional military conflict.³⁷ On the other hand, former Commander in Chief of *U.S. Pacific Command* Dennis C. Blair has stated that "U.S. planners are very mindful of the danger of attacking any state's nuclear arsenal and take extraordinary precautions to avoid doing so."³⁸

A similar threshold involves strikes against an adversary's dual-capable military assets—that is, capabilities serving both nuclear and nonnuclear functions.³⁹ Russia and China field a wide variety of dual-capable aircraft and missiles that can be equipped with both conventional and nuclear warheads.⁴⁰ China's multirole DF-26 missile is even "designed to rapidly swap conventional and nuclear warheads" in the field, and the Chinese People's Liberation Army Rocket Force is responsible for both nuclear deterrence *and* conventional deterrence and warfighting.⁴¹ Furthermore, C5ISR capabilities are increasingly "entangled," meaning they enable both nuclear and nonnuclear operations and are vulnerable to nuclear and nonnuclear attack.⁴²

Because of this entanglement, U.S. military operations against an adversary's conventional military forces and C5ISR facilities could inadvertently degrade nuclear command and control, prompting the enemy to escalate due to fears about the survivability of its nuclear forces.⁴³ Political scientist Caitlin Talmadge has argued that in a conventional war with China, U.S. military operations "almost certainly would erode significant components of China's nuclear or nuclear-relevant capabilities even if this were not the U.S. goal."⁴⁴ The U.S. military is also likely to target critical C5ISR assets early in conflict.⁴⁵ The current commander of Indo-Pacific Command, Admiral Samuel Paparo, described counter-C5ISR as

36 Tong Zhao, "Conventional Long-Range Strike Weapons of US Allies and China's Concerns of Strategic Instability," *Nonproliferation Review* 27, no. 1–3 (February–June 2020): 109–122, <https://doi.org/10.1080/10736700.2020.1795368>; and James M. Acton, "Russia and Strategic Conventional Weapons: Concerns and Responses," *Nonproliferation Review* 22, no. 2 (June 2015): 141–54, <https://doi.org/10.1080/10736700.2015.1105434>. On conventional counterforce, see Bowers and Hiim, "Conventional Counterforce Dilemmas"; and Hoffmann, "Strategic-Level Effects."

37 Posen, "Inadvertent Nuclear War."

38 Dennis C. Blair and Caitlin Talmadge, "Would China Go Nuclear?," *Foreign Affairs* 98, no. 1 (January/February 2019), <https://www.foreignaffairs.com/articles/china/2018-12-11/would-china-go-nuclear>.

39 Goldfeld et al., *Denial Without Disaster*, 15.

40 James M. Acton, *Is It a Nuke? Pre-Launch Ambiguity and Inadvertent Escalation* (Washington, DC: Carnegie Endowment for International Peace, 2020), 18–23, <https://carnegieendowment.org/research/2020/04/is-it-a-nuke-pre-launch-ambiguity-and-inadvertent-escalation>.

41 U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2024: Annual Report to Congress* (Washington, DC: U.S. Department of Defense, 2024), 65, <https://media.defense.gov/2024/Dec/18/2003615520/-1/-1/0/MILITARY-AND-SECURITY-DEVELOPMENTS-INVOLVING-THE-PEOPLES-REPUBLIC-OF-CHINA-2024.PDF>; and 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): 447–87, <https://doi.org/10.1080/01402390.2012.714710>.

42 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, https://doi.org/10.1162/isec_a_00320.

43 Ibid.

44 Talmadge, "Would China Go Nuclear?"

45 See, for example, U.S. Department of the Army, *Field Manual 3-0: Operations* (Washington, DC: U.S. Department of the Army, 2022), 6–24, archived at https://web.archive.org/web/20250215140030/https://armypubs.army.mil/epubs/DR_pubs/DR_a/ARN36290-FM_3-0-000-WEB-2.pdf; and Air-Sea Battle Office, "Air-Sea Battle: Service Collaboration to Address Anti-Access & Area Denial Challenges," Air and Space Forces, May 2013, https://www.airandspaceforces.com/PDF/DRArchive/Documents/2013/June%202013/AirSea_Battle_Concept_summary_May_2013.pdf.

“the number one priority” in his confirmation hearing.⁴⁶ Yet such strikes also raise the risk of crossing an escalatory threshold and could accelerate an adversary’s decision to use nuclear weapons.⁴⁷

The third threshold in this category involves attacks on civilian infrastructure, especially if they lead to significant civilian casualties—something that has long been considered an important escalatory threshold.⁴⁸ As a general rule, the U.S. military does not target the civilian population and other protected persons and objects, as this would violate the principle of distinction under the law of war.⁴⁹ Notwithstanding, it considers an object a legitimate military target if it makes “an effective contribution to military action” or is intended to do so. This includes war-supporting and war-sustaining contributions—which do not necessarily entail direct or proximate contributions or immediate tactical or operational advantage.⁵⁰

During Operation Desert Storm in 1991, U.S. airstrikes damaged or destroyed nearly 88 percent of Iraq’s electrical generation capacity, causing widespread blackouts and grid failures soon after the air campaign began.⁵¹ The resulting power outages across central and southern Iraq had serious consequences for the civilian population, including reduced hospital services, disruptions to water purification and distribution, and a decline in crop production.⁵² Unlike in 1991, coalition forces largely spared Iraqi civilian infrastructure during the 2003 invasion, and the U.S. military has taken significant measures over the past two decades to minimize civilian casualties.⁵³ However, the recent DOD focus on “lethality”—and the associated elimination of its Civilian Harm Mitigation and Response Plan and the closure of the Civilian Protection Center of Excellence—would seem to imply an increased tolerance for civilian casualties, suggesting that this escalatory threshold could become more important in the future.⁵⁴

TEMPO-OF-OPERATIONS THRESHOLDS

The risk of inadvertent or accidental nuclear escalation depends not only on which targets are selected and where they are located, but also on how they are struck. The mode and tempo of military operations can themselves constitute critical escalatory thresholds, shaping how actions are interpreted by an adversary. Shock-and-awe campaigns or rapid, large-scale strikes by U.S. forces could create a sense of desperation among enemy leaders, increasing the risk that they might respond with nuclear weapons. Similarly, the large-scale deployment of long-range strike assets into a theater of operations during a conventional conflict could signal the onset of a high-tempo strike

46 Jon Harper, “Counter-C5ISR is Top Priority for Nominee to Lead Indo-Pacific Command,” *DefenseScoop*, February 1, 2024, <https://defensescoop.com/2024/02/01/counter-c5isr-samuel-paparo-indo-pacific-command-nomination/>.

47 Rovner, “Two Kinds of Catastrophe.”

48 Goldfeld et al., *Denial Without Disaster*, 15; and Kahn, *On Escalation*, 179–80.

49 General Counsel of the Department of Defense, *Department of Defense Law of War Manual* (Washington, DC: U.S. Department of Defense, 2023), 212–14, <https://media.defense.gov/2023/Jul/31/2003271432/-1/-1/0/DOD-LAW-OF-WAR-MANUAL-JUNE-2015-UPDATED-JULY%202023.PDF>.

50 *Ibid.*, 221–22. However, proportionality considerations still apply: See Joint Chiefs of Staff, *Joint Targeting* (Washington, DC: U.S. Department of Defense, 2013), A-5, https://www.justsecurity.org/wp-content/uploads/2015/06/Joint_Chiefs-Joint_Targeting_20130131.pdf.

51 Eliot A. Cohen, *Gulf War Air Power Survey, Volume 2: Operations and Effects and Effectiveness* (Washington, DC: U.S. Department of the Air Force, 1993), 124, 126, 290–312, <https://apps.dtic.mil/sti/citations/ADA279742>.

52 J. W. Crawford III, “The Law of Noncombatant Immunity and the Targeting of National Electrical Power Systems,” *Fletcher Forum of World Affairs* 21, no. 2 (Summer/Fall 1997): 101–119, <https://www.jstor.org/stable/45289003>.

53 Marc Garlasco, “Pentagon Releases First-Ever Policy on Civilian Harm Reduction,” *Lawfare*, December 22, 2023, <https://www.lawfaremedia.org/article/pentagon-releases-first-ever-policy-on-civilian-harm-reduction>; and Colin H. Kahl, “In the Crossfire or the Crosshairs? Norms, Civilian Casualties, and U.S. Conduct in Iraq,” *International Security* 32, no. 1 (Summer 2007): 7–46, <https://doi.org/10.1162/isec.2007.32.1.7>.

54 Claire Finkelstein, “The Pentagon is about to Make a Big Mistake on Civilian Harm Mitigation,” *War on the Rocks*, March 5, 2025, <https://warontherocks.com/2025/03/the-pentagon-is-about-to-make-a-big-mistake-on-civilian-harm-mitigation/>.

campaign, potentially creating pressure on an adversary to consider nuclear preemption.⁵⁵

This escalatory threshold appears particularly salient due to the U.S. military's doctrinal preference for high-tempo operations. During Operation Desert Storm in 1991, coalition forces struck about 1,200 targets within the first 24 hours.⁵⁶ In the opening phase of the air campaign, U.S. Army attack helicopters first destroyed two Iraqi early warning radars, opening a 10 km corridor for Air Force jets to attack Scud sites. Minutes later, stealth aircraft bombed key command and control nodes, including the Air Force headquarters, Air Defense Operating Center, and presidential palace. Simultaneously, 52 Tomahawk cruise missiles hit targets across Baghdad, including power plants, chemical facilities, and regime leadership sites. Subsequent waves targeted air defenses and airfields, rapidly degrading Iraq's ability to respond.⁵⁷ But while this approach to warfighting achieved decisive operational success against a nonnuclear regional adversary, its application against a nuclear-armed opponent could plausibly trigger nuclear employment as a last resort.⁵⁸

ESCALATION MANAGEMENT IN THE JOINT TARGETING PROCESS

The U.S. military defines targeting as “the process of selecting and prioritizing targets and matching the appropriate response to them, considering operational requirements and capabilities.”⁵⁹ The issue of escalation management is not explicitly addressed in official U.S. targeting doctrine, which does nevertheless emphasize that certain targets “may require special care or caution in treatment because attacking them improperly could lead to adverse consequences.”⁶⁰ The Joint Chiefs of Staff explicitly lists the following as examples: leadership targets, which could result in political or diplomatic consequences; targets located in areas with a high collateral damage expectancy; and weapons of mass destruction (WMD) facilities. In such cases, using nonlethal capabilities against these targets “may reduce the potential for unintended consequences that are detrimental to the [Joint Force Commander's] strategic goals.”⁶¹

The joint targeting cycle includes several processes that can help reduce the risk of inadvertent or accidental escalation. These processes—the Sensitive Target Approval and Review process, the Collateral Damage Estimation Methodology, and the No-Strike and Restricted Target List—either require national-level approval for sensitive strikes or restrict attacks on specific targets, thereby lowering the likelihood of unintentionally crossing the key escalatory thresholds identified above. This section considers all of them in turn and discusses how they could help the DOD manage escalation.

SENSITIVE TARGET APPROVAL AND REVIEW PROCESS

The Sensitive Target Approval and Review (STAR) process outlines a set of procedures for combatant commanders to identify targets that are considered “sensitive” and forward them to the secretary of defense or the president for review and approval.⁶² Although the criteria for classifying a target as

55 Goldfeld et al., *Denial Without Disaster*, 26–27.

56 Thomas A. Keaney and Eliot A. Cohen, *Gulf War Air Power Survey: Summary Report* (Washington, DC: U.S. Department of the Air Force, 1993), 13, <https://doi.org/10.21236/ada273996>.

57 Cohen, *Gulf War Air Power Survey, Volume 2*, 120–24.

58 Goldfeld et al., *Denial Without Disaster*, 27; Michael Kofman, “It's Time to Talk about A2/AD: Rethinking the Russian Military Challenge,” *War on the Rocks*, September 5, 2019, <https://warontherocks.com/2019/09/its-time-to-talk-about-a2-ad-rethinking-the-russian-military-challenge/>.

59 Joint Chiefs of Staff, *Joint Targeting*, vii.

60 *Ibid.*, 1–8.

61 *Ibid.*

62 Joint Chiefs of Staff, *Sensitive Target Approval and Review (STAR) Process* (Washington, DC: U.S. Department of Defense, 2018), A-5, <https://int.nyt.com/data/documenttools/sensitive-target-approval/1feed7477ddf540/full.pdf>.

“sensitive” are themselves classified, publicly available doctrine suggests that targets are deemed sensitive when military action against them poses risks such as high collateral damage to civilian populations or infrastructure, political or diplomatic fallout, environmental hazards, or significant negative public repercussions, both domestically and internationally.⁶³ Also considered sensitive are targets of cyberspace operations that are reasonably expected to cause loss of life, provoke significant retaliatory actions against the United States, inflict major property damage, result in serious negative consequences for U.S. foreign policy, or have a substantial economic impact on the United States.⁶⁴

Because the STAR process helps ensure that military operations are conducted in accordance with national policy and that national-level leadership is fully informed of the potential consequences of striking high-risk or politically sensitive targets, it appears well positioned to reduce the risk of unintended nuclear escalation. Together with the intelligence community, the DOD could explore whether it is possible to identify which enemy targets pose a particularly high risk of nuclear escalation if attacked and whether it is feasible to augment sensitive target criteria to include at least some of these targets. Given the escalatory thresholds identified above, special focus should be given to locations within the adversary’s territory and near the capital, an adversary’s nuclear forces and military assets supporting nuclear operations, and dual-use infrastructure that may result in significant civilian loss of life. While U.S. military leadership would likely exercise extreme caution around such targets, formally classifying them as sensitive would provide an additional safeguard.

COLLATERAL DAMAGE ESTIMATION METHODOLOGY

The U.S. military’s Collateral Damage Estimation Methodology (CDEM) seeks to limit civilian harm by having commanders pose five key questions before striking a target. First, can the object be clearly identified as a lawful military target under the law of war and rules of engagement? Second, would civilians, protected sites, infrastructure, or environmental hazards be affected? Third, can collateral damage be reduced by using a different weapon or mode of attack? Fourth, if not, how many civilians are likely to be harmed? Fifth, is that harm excessive relative to the military advantage, requiring approval from a higher-level commander?⁶⁵ This methodology not only helps avoid or mitigate civilian casualties, it also directly supports the STAR process by identifying when a strike carries the risk of excessive collateral damage that warrants higher-level review by the secretary of defense or the president.⁶⁶ Prior to the 2003 invasion of Iraq, the CDEM was used to condense an initial list of approximately 11,000 targets with high risk of collateral damage to only about two dozen; these were subsequently reviewed by Secretary of Defense Donald Rumsfeld and President George W. Bush.⁶⁷

Since attacks that cause significant civilian casualties are an important escalatory threshold, CDEM is not only important for civilian harm mitigation, but also for preventing escalation. The DOD could therefore examine whether there is benefit in explicitly emphasizing the escalation management function of the CDEM process in joint doctrine. Moreover, it could reconsider the elimination of the

63 Joint Chiefs of Staff, *Joint Targeting*, I-8.

64 Joint Chiefs of Staff, *STAR Process*, A-4.

65 Joint Chiefs of Staff, *No-Strike and Collateral Damage Estimation Methodology* (Washington, DC: U.S. Department of Defense, 2009), D-A-7, <https://www.aclu.org/documents/no-strike-and-collateral-damage-estimation-methodology>; and Kahl, “In the Crossfire.”

66 Joint Chiefs of Staff, *No-Strike and Collateral Damage*, D-4; Kahl, “In the Crossfire”; John Cherry, Kieran Tinkler, and Michael Schmitt, “Avoiding Collateral Damage on the Battlefield,” *Just Security*, February 11, 2021, <https://www.justsecurity.org/74619/avoiding-collateral-damage-on-the-battlefield/>; and Joint Chiefs of Staff, *Joint Targeting*, II-16.

67 Kahl, “In the Crossfire.”

Civilian Harm Mitigation and Response Plan and the Civilian Protection Center of Excellence.

NO-STRIKE LIST

The No-Strike List (NSL) identifies “objects or entities characterized as protected from the effects of military operations under international law and/or rules of engagement.”⁶⁸ Striking objects on this list requires authorization from national-level leadership.⁶⁹ No-strike objects include, but are not limited to, medical facilities, schools, diplomatic missions, cultural and religious sites, historical landmarks, and other locations that do not directly support a nation’s military operations. These sites are identified as civilian or noncombatant in nature and are generally not lawful targets under normal circumstances. Attacks on no-strike entities or objects may not only violate the laws of war; they could also “interfere with friendly relations with indigenous personnel or governments.”⁷⁰ The NSL can be extensive; in Operation Iraqi Freedom, for instance, it listed 12,700 sites.⁷¹ Depending on the military or political situation, however, the secretary of defense or the president may also modify the protected or collateral object categories on the NSL, which will be reflected in the rules of engagement.⁷²

Similarly to the CDEM process, the NSL could also be an important tool for managing escalation, as it seeks to limit civilian casualties and prohibit, among other things, strikes against cultural sites that could provoke an emotional, escalatory response. Together with the intelligence community, the DOD could study how modifying collateral and protected object categories on the NSL might affect the risk of nuclear escalation to gain a better understanding of the relationship between civilian harm mitigation and escalation management. In addition, it could study whether prohibitions in the rules of engagement on targeting dual-use objects that have both military and civilian purposes could further reduce the risk of unintended nuclear escalation, and to what extent such prohibitions would be feasible from a military effectiveness point of view.

RESTRICTED TARGET LIST

In contrast to the NSL, the restricted target list (RTL) contains valid military targets, but those with “specific restrictions placed on the actions authorized against . . . [them] due to operational considerations.”⁷³ Besides potential interference with friendly operations, other reasons a target can be listed include political concerns, intelligence gain or loss, environmental risks, potential collateral damage, and rules of engagement. These targets may still be struck if all restrictions are followed, but any action that goes beyond these limitations is prohibited unless coordinated with and approved by the headquarters that imposed them. Restrictions can include the requirement to strike the target with nonlethal means, for example, or only at a certain time of the day with a specific weapon.⁷⁴

The RTL is well suited to lowering nuclear escalation risks because it rules out only certain types of action against a target, striking a balance between military necessity and escalation management. Non-kinetic means such as cyber operations, for example, are often viewed as less escalatory alternatives to kinetic strikes.⁷⁵ Taking this into account, the DOD and the intelligence community

68 Joint Chiefs of Staff, *No-Strike and Collateral Damage*, GL-7.

69 U.S. Air Force, *Targeting* (Washington, DC: U.S. Department of Defense, 2021), 48, https://www.doctrine.af.mil/Portals/61/documents/AFDP_3-60/3-60-AFDP-TARGETING.pdf.

70 Joint Chiefs of Staff, *No-Strike and Collateral Damage*, GL-7; and Cherry, Tinkler, and Schmitt, “Avoiding Collateral Damage.”

71 Kahl, “In the Crossfire.”

72 Joint Chiefs of Staff, *No-Strike and Collateral Damage*, B-7.

73 Joint Chiefs of Staff, *Joint Targeting*, II-13.

74 Ibid.; and Cherry, Tinkler, and Schmitt, “Avoiding Collateral Damage.”

75 Benjamin Jensen and Brandon Valeriano, “What Do We Know about Cyber Escalation? Observations from Simulations and

could explore the extent to which the use of nonlethal or non-kinetic strikes might be an effective yet less escalatory substitute for kinetic attacks. This may be especially relevant when targeting homeland targets and dual-capable military assets, where an attack would likely provide clear military advantage yet carry a high risk of escalation.

CONCLUSION

If the United States becomes involved in a military conflict with a nuclear-armed adversary, there is a significant risk the adversary could employ nuclear weapons. While deliberate escalation can be managed through deterrence, reducing the risk of inadvertent or accidental escalation requires effective escalation and force management, including awareness of key thresholds. These thresholds may be difficult to identify in advance, vary by adversary, and shift over the course of a conflict. Yet probable escalatory thresholds include high-tempo operations and strikes on the adversary's homeland and capital, nuclear forces and supporting assets, or dual-use infrastructure that could cause significant civilian casualties.

The DOD could use existing processes in the joint targeting cycle to implement targeting restrictions based on key thresholds, helping keep conventional conflict under the nuclear threshold. However, there is an inherent tension between devising practical targeting restrictions to reduce the risk of escalation and not constraining military effectiveness.⁷⁶

A closer study of how specific targeting restrictions could support escalation management can inform decisionmaking during a crisis and ensure that the risks of conventional military operations are well understood. Such a study could explore whether targeting restrictions using the STAR process, CDEM, the NSL, and the RTL can be implemented in a way that balances escalation management with military effectiveness. It could also examine the feasibility of limiting, in some shape or form, the speed, simultaneity, or scope of military operations to further reduce the risk of escalation. However, targeting restrictions will likely be most effective when paired with military-to-military communications and other diplomatic tools. For example, if the United States decides to strike an adversary's dual-capable military assets to stop attacks on U.S. forces, it could communicate that its intent is not to degrade the adversary's secure second-strike capability.

In any case, the issue of escalation management in conventional military conflict will remain critically important for the foreseeable future. The more people think through these issues inside and outside government, the less likely it is that nuclear weapons will be employed for a third time in history.

Surveys," Atlantic Council, November 22, 2019, <https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/what-do-we-know-about-cyber-escalation-observations-from-simulations-and-surveys/>. See also Goldfeld et al., *Denial Without Disaster*, 30.

76 Goldfeld et al., *Denial Without Disaster*, 29–30.



More Kill Vehicles, More Problems

The Next-Generation Interceptor and Crisis Stability

By Sam Lair¹

INTRODUCTION

The Trump administration has announced a dramatic expansion of the U.S. missile defense program as part of its Golden Dome initiative. The Iron Dome for America executive order, issued in January 2025, called for a “next-generation missile defense shield” to protect the United States against missile and air attacks.² This growth builds on the existing modernization program for U.S. homeland missile defenses, including Lockheed Martin’s Next Generation Interceptor (NGI) system, whose signature innovation is to deliver multiple kill vehicles rather than a single exoatmospheric kill vehicle as the existing Ground-Based Interceptor (GBI) does.³ These kill vehicles use kinetic energy to destroy enemy reentry vehicles, crashing into them at high speeds above the atmosphere—sometimes likened to “hitting a bullet with a bullet.”⁴

Adversaries will likely account for this new capability when planning their nuclear forces. So how will the use of multiple kill vehicles impact crisis stability between the United States and its nuclear-armed adversaries? While it is difficult to predict exactly how adversaries will react to the NGI deployments, examining past responses to anti-ballistic missile (ABM) technologies suggests some strategies they might pursue to thwart these improved interceptors. After reviewing recent efforts to improve

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- 1 Sam Lair is a research associate on the Open-Source Intelligence Team at the Center for Nonproliferation Studies and a fellow in the National Security Program at the Foreign Policy Research Institute.
 - 2 “Executive Order 14186 of January 27, 2025, The Iron Dome for America,” *Federal Register* 90, no. 21 (February 3, 2025): 8767, <https://www.federalregister.gov/documents/2025/02/03/2025-02182/the-iron-dome-for-america>.
 - 3 U.S. Department of Defense, “Fiscal Year (FY) 2024 Budget Estimates Overview,” Missile Defense Agency, March 13, 2023, <https://www.mda.mil/global/documents/pdf/MDA%20FY24%20Budget%20Booklet.pdf>.
 - 4 Kenneth P. Warrell, “Hitting a Bullet with a Bullet: A History of Ballistic Missile Defense,” Airpower Research Institute, 2000, <https://apps.dtic.mil/sti/html/tr/ADA381863/>.

the Ground-Based Midcourse Defense (GMD) program and the prohibition of multiple warheads on interceptors under the 1972 Anti-Ballistic Missile (ABM) Treaty, this paper examines the effects on crisis stability of three potential adversary responses to multiple kill vehicles and their effect on crisis stability: oversaturation of defenses, staggered launches, and early strikes on ABM infrastructure.

Though not all the strategies examined here would have adverse impacts on crisis stability, some of the force structures and postures considered could be detrimental to the nuclear balance between the United States and its adversaries. To lessen the incentives for other nations to pursue destabilizing force structures and strategies while still improving the effectiveness of its own ABM systems, Washington should refrain from further pursuit of multiple kill vehicles and deploy NGIs with a single upgraded kill vehicle each.

BACKGROUND: THE NGI PROGRAM AND THE RELEVANCE OF THE ABM TREATY

The Department of Defense (DOD) and the Missile Defense Agency have taken many steps to improve the GMD system since the early 2000s. The most recent was the Redesigned Kill Vehicle program, which the DOD canceled in 2019—after having already spent \$1.2 billion—once the estimated total cost tripled and the timeline had been delayed by four years.⁵ The NGI was announced shortly thereafter, and reporting quickly identified this new interceptor as being designed to deliver multiple kill vehicles.⁶ As of writing, the Missile Defense Agency plans to improve and modernize the GMD program by adding 21 NGIs to the existing 44 GBIs emplaced at Fort Greely in Alaska and Vandenberg Space Force Base in California.⁷ It is unclear how many kill vehicles will be deployed on each NGI, but if each has at least two and no GBIs are retired, then the total number of deployed U.S. kill vehicles could expand from 44 to at least 86.

Multiple kill vehicles could help address adversary countermeasures to ABM systems, particularly the use of decoys. The challenge of discriminating between reentry vehicles and decoys has bedeviled ABM systems for the better part of a century, and multiple kill vehicles would allow each interceptor to target more objects in each “threat cloud” released by a ballistic missile. However, as the number of kill vehicles on each interceptor increases, the size of each kill vehicle, and concomitantly its sensing and divert capability, will decrease.⁸

By April 2021, the NGI program was projected to cost \$17.7 billion for 21 interceptors to replace 20 of the aging GBIs.⁹ However, this number could increase, as the 2023 Strategic Posture Commission

5 Jen Judson, “Cost Tripled for Missile Defense Warhead, Despite Prior Warnings, GAO Finds,” *Defense News*, July 23, 2020, <https://www.defensenews.com/land/2020/07/23/canceled-missile-defense-warheads-cost-tripled-schedule-slipped-despite-numerous-warnings-gao-finds/>.

6 Loren Thompson, “Inside the U.S. Missile Defense Agency’s Secret Next Generation Interceptor,” *Forbes*, October 8, 2019, <https://www.forbes.com/sites/lorenthompson/2019/10/08/inside-the-missile-defense-agencys-secret-next-generation-interceptor/#6c48e5b52663>.

7 Paul McLeary, “DoD Estimates New Missile Defense Program to Cost \$17.7B,” *Breaking Defense*, April 27, 2021, <https://breakingdefense.com/2021/04/dod-estimates-missile-defense-program-to-cost-17-7b/>; and U.S. Department of Defense, “Department of Defense Press Briefing on the President’s Fiscal Year 2019 Defense Budget for the Missile Defense Agency,” press release, February 13, 2018, <https://www.war.gov/News/Transcripts/Transcript/Article/1440326/department-of-defense-press-briefing-on-the-presidents-fiscal-year-2019-defense/>.

8 National Resource Council, *Making Sense of Ballistic Missile Defense: An Assessment of Concepts and Systems for U.S. Boost-Phase Missile Defense in Comparison to Other Alternatives* (Washington, DC: National Academies Press, 2012), 148–49, <https://nap.nationalacademies.org/catalog/13189/making-sense-of-ballistic-missile-defense-an-assessment-of-concepts>.

9 McLeary, “DoD Estimates.”

suggested additional NGIs/GBIs may be needed to pace the North Korean threat and address what it saw as an increased missile threat to the continental United States.¹⁰ To this end, the FY 2023 National Defense Authorization Act directed the Missile Defense Agency to submit a report to Congress outlining a plan for acquiring no less than 64 NGIs.¹¹ Some estimates suggest each additional interceptor could cost \$111 million, perhaps more.¹² Importantly, the kill vehicle is the most expensive component, amounting to 42 percent of interceptor costs for one particular GBI model, which only totaled about \$70 million, suggesting much of the cost difference between old and new systems might be due to the additional kill vehicles.¹³

Despite the apparent novelty of multiple kill vehicles and the lack of discussion regarding their strategic effects, this technology was banned as part of the Strategic Arms Limitation Talks (SALT). The 1972 ABM Treaty limited the United States and the Soviet Union to two missile defense sites of 100 interceptors each, later revised to a single site each. The treaty also placed qualitative restrictions on defenses, including an agreed statement that obliged states “not to develop, test or deploy ABM interceptor missiles for the delivery by each ABM interceptor missile of more than one independently guided warhead.”¹⁴ However, there has been little discussion, at least in English-language sources, about why these interceptors were banned.

Gerard Smith, the Arms Control and Disarmament Agency head and lead U.S. negotiator for SALT from 1969–1972, explained in his memoir *Doubletalk* that the “important qualitative limitation” on multiple warheads for ABM interceptors emerged organically from discussions between SALT delegations on restricting reload of ABM launchers and that the wording of the agreed statement was proposed by lead Soviet negotiator Vladimir Semyonov.¹⁵ Smith concluded, “Here were good examples of controlling technology before it was developed and of the feasibility of putting limitations on the qualitative characteristics as well as the numbers of weapons systems.”¹⁶ Despite the fact that the ABM Treaty was abrogated by the George W. Bush administration in 2002, the limit on multiple warhead interceptors set a precedent for restraint in this area that could form the foundation for a formal or informal understanding between states pursuing advanced ABM systems today.

METHODOLOGY

This paper examines three strategies adversaries could pursue in response to multiple kill vehicles. It outlines each strategy, identifies historical antecedents, and assesses how the force structures and approaches it encourages or requires would affect crisis stability.

James Acton suggests that under the “traditional” conception of stability, “a crisis can be defined as stable if neither side has or perceives an incentive to use nuclear weapons first out of the fear that the other side is about to do so.”¹⁷ Acton’s definition builds on Thomas Schelling’s argument that

10 Madelyn R. Creedon et al., *America’s Strategic Posture: The Final Report of the Congressional Commission on the Strategic Posture of the United States* (Alexandria, VA: Institute for Defense Analyses, 2023), 66, 72, <https://www.ida.org/research-and-publications/publications/all/a/am/americas-strategic-posture>.

11 Ibid., 67.

12 Kingston Reif and Shannon Bugos, “New ICBM Interceptor to Cost \$18 Billion,” *Arms Control Today*, June 2021, <https://www.armscontrol.org/act/2021-06/news/new-icbm-interceptor-cost-18-billion>.

13 National Research Council, *Making Sense of Ballistic Missile Defense*, 255.

14 “Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems (ABM Treaty),” signed May 26, 1972, <https://2009-2017.state.gov/t/avc/trty/101888.htm>.

15 Gerard C. Smith, *Doubletalk: The Story of the First Strategic Arms Limitation Talks* (New York: Doubleday, 1980), 367–68.

16 Ibid.

17 James Acton, “Reclaiming Strategic Stability,” in *Strategic Stability: Contending Interpretations*, eds. Elbridge A. Colby and

stability is not defined by symmetry in capabilities and forces; rather, “the balance is stable only when neither, in striking first, can destroy the other’s ability to strike back.”¹⁸ Likewise, Glenn Snyder observes that stability is not an absolute state of affairs, elaborating, “The basic criterion of stability in the balance of terror is the ‘distance’ which both sides are from possessing a full first-strike capability.” In other words, the closer two adversaries are to full first-strike capability, the more prone their relationship is to conflict and escalation.¹⁹ This piece is concerned with whether adversary responses to multiple kill vehicles narrow this distance and generate incentives to use nuclear weapons in a conflict out of fear the other side is about to strike.

This analysis draws on the multiple independently targetable reentry vehicle (MIRV) theory of instability, a subset of crisis stability. As Christopher Ford describes it, silo-based missiles with MIRVs are destabilizing since a single MIRVed missile can hold several targets at risk, while “a single attacking weapon, hitting a MIRVed missile in its silo, can take several enemy warheads out of action with the expenditure of but a single attacking warhead,” meaning “mutual possession of MIRVs makes preemption incentives especially high.”²⁰ This situation creates mutual first strike pressures and encourages the introduction of other policies such as launch on warning, which may be more susceptible to false alarms or accidents.²¹ MIRVs closely align with what Schelling describes as “strike-first” weapons, which, because of their vulnerability and utility for preemption,

not only give their possessor a powerful incentive to strike first, and an incentive to jump the gun in the event of ambiguous warning rather than to wait and make absolutely sure; they are a tacit declaration to the enemy that one expects to strike first. They consequently invite the enemy to strike a little before *that* and to act with haste in the event he thinks that we think it’s time to act quickly.²²

While the destabilizing attributes of MIRVed missiles can be reduced by introducing survivability through mobility, as with the Russian Yars intercontinental ballistic missile (ICBM), they are still destabilizing due to their utility as first-strike weapons and their concomitant effects on force exchange ratios.²³

As attention within the U.S. nuclear policy community increasingly turns toward limited conflicts with adversaries, crisis stability is an appropriate lens through which to view these reactions. It is important to consider how strategic-level systems such as homeland missile defenses may have ripple effects on adversary decisionmaking and create or reinforce escalation pathways in lower-level conflicts.

Assuming adversaries are taking measures to counter U.S. deployments, then the deployment of multiple kill vehicles will generate arms race instability, which Acton defines as “the absence of perceived or actual incentives to augment a nuclear force—qualitatively or quantitatively—out of

Michael S. Gerson (Carlisle, PA: U.S. Army War College Press, 2013), 121, <https://apps.dtic.mil/sti/tr/pdf/ADA572928.pdf>.

18 Thomas Schelling, *The Strategy of Conflict* (Cambridge, MA: Harvard University Press, 1960), 269.

19 Glenn H. Snyder, “Balance of Power and the Balance of Terror” in *Balance of Power*, ed. Paul Seabury (San Francisco, CA: Chandler Publishing Company, 1965), 197.

20 Christopher A. Ford, “Anything but Simple: Arms Control and Strategic Stability,” in *Strategic Stability: Contending Interpretations*, eds. Elbridge A. Colby and Michael S. Gerson (Carlisle, PA: U.S. Army War College Press, 2013), 227, <https://apps.dtic.mil/sti/tr/pdf/ADA572928.pdf>. Ford acknowledges this is somewhat of an oversimplification of nuclear targeting, in which multiple warheads would be assigned to each target.

21 *Ibid.*, 227–28.

22 Schelling, *Strategy of Conflict*, 279.

23 Brent Scowcroft et al., *Report of the President’s Commission on Strategic Forces* (Washington, DC: 1983), 15–16, 18–19. <https://web.mit.edu/chemistry/deutch/policy/1983-ReportPresCommStrategic.pdf>

the fear that in a crisis an opponent would gain a meaningful advantage by using nuclear weapons first.”²⁴ It seems reasonable to assume multiple kill vehicles will upset strategic stability since, as Schelling noted, “Each of us in his own program must influence the other in some fashion. The influence is surely complicated and uneven, indirect and occasionally irrational, and undoubtedly based often on inaccurate projections of each other’s programs. But the influence is there.”²⁵

Finally, this analysis assumes a highly capable multiple kill vehicle system in which one interceptor can attack several objects in the threat cloud released by a single ballistic missile. While details of the performance of multiple kill vehicles are not publicly known, adversaries likely would assume the same when accounting for NGIs. Even if the multiple kill vehicles’ actual capabilities are more limited, these adversaries would plan their forces and posture around them being highly effective.

ANALYSIS

ADVERSARY STRATEGY 1: OVERSATURATE DEFENSES

The classic way to overcome an ABM system is oversaturation, increasing the number of potential threats to which the system must respond and exhausting the interceptor magazine. Broadly, there are two strategies for doing so: increase the number of countermeasures each missile carries, such as decoys, or increase the number of warheads.

The British pursued countermeasure-based oversaturation in response to the Soviet ABM system around Moscow in the late 1960s and early 1970s. Each Chevaline, the countermeasure system that eventually emerged after a tumultuous development program, carried 27 inflatable decoys to confuse defenses and draw off interceptors from the two reentry vehicles.²⁶ Against the 64 interceptors deployed around Moscow, this was an effective way to ensure the British would be able to overcome Soviet ABMs.²⁷

While the United States considered pursuing decoy-based oversaturation—indeed, its Super Antelope system was the predecessor to Chevaline—Washington chose to pursue warhead-based saturation of Soviet defenses, developing multiple reentry vehicle and MIRV systems to overwhelm any Soviet defense.²⁸ The Polaris A3 missile, for example, had three reentry vehicles in a multiple reentry vehicle configuration so it could defeat an endoatmospheric ABM system, and other missile systems such as Poseidon were MIRVed to oversaturate defenses.²⁹

There is also a synthesis option, using both multiple warheads and decoys to overwhelm defenses. The United States’ Minuteman III had three reentry vehicles and a countermeasure package consisting of chaff and decoys, while the Soviet Union’s SS-18 carried large numbers of reentry vehicles and inflatable decoys.³⁰

24 Acton, “Reclaiming Strategic Stability,” 121.

25 Thomas Schelling, *Arms and Influence* (New Haven, CT: Yale University Press, 1966), 271.

26 Matthew Jones, *The Official History of the UK Strategic Nuclear Deterrent Volume II: The Labour Government and the Polaris Programme, 1964-1970* (London: Routledge, 2017), x–xi.

27 Central Intelligence Agency, *National Intelligence Estimate: Soviet Strategic Defenses* (Washington, DC: Central Intelligence Agency, 1972), 3, https://www.cia.gov/readingroom/docs/DOC_0005363585.pdf.

28 Jones, *Official History*, 352–53.

29 *Ibid.*, 352–53; and Graham Spinardi, *From Polaris to Trident: The Development of US Fleet Ballistic Missile Technology* (Cambridge, United Kingdom: Cambridge University Press, 1994), 68.

30 David K. Stumpf, *Minuteman: A Technical History of the Missile That Defined American Nuclear Warfare* (Fayetteville, AR: University of Arkansas Press, 2020), 3; and Steven J. Zaloga, *The Kremlin’s Nuclear Sword: The Rise and Fall of Russia’s Strategic Nuclear Forces, 1945-2000* (Washington, DC: Smithsonian Books, 2002), 128–32, 235.

Developing more effective countermeasures packages would be the least expensive way to defeat multiple kill vehicles and would build on the many decades of work China and Russia have already put into decoys and other countermeasures.³¹ Adding more decoys, in essence mylar balloons shaped and heated to resemble a reentry vehicle, would be cheaper and easier than producing more or larger launchers to deliver additional warheads. Anti-simulation measures could also be taken, giving different signatures to each decoy and reentry vehicle so none of them stick out.³² Moreover, the active Russian and Chinese mid-course ABM programs will likely improve their countermeasures as they develop a sense of the effectiveness of decoys, chaff, and other penetration aids.³³ If the adversary can generate dozens of credible decoys per missile, it would be very difficult for the United States to keep pace with the ballistic missile threat, even with multiple kill vehicles.

Yet adversaries may have incentives to prioritize MIRVing over large decoy packages. First, decoys have a trade-off with payload weight, reducing the number or yield of warheads delivered to target. A countermeasure system developed for the Polaris A3, for example, would “trade” one of the missile’s three warheads for a Penetration Aid Carrier.³⁴ Second, MIRVing has certain cost efficiencies, including reducing the overall number of propulsion, guidance, and launcher systems an adversary would need to procure. While the individual cost of those ICBMs might be higher due to MIRVing, the number of ICBMs procured would be lower, and the cost per warhead delivered would be lower as well.³⁵ While it seems more likely that adversaries will pursue oversaturation via decoys, they have some incentives to consider a MIRV-based solution as well.

Whether these responses would reduce crisis stability depends on how the oversaturation strategy is crafted. Additional decoys or launchers might not be destabilizing, and expanded countermeasures packages might even reassure adversaries of their ability to overcome U.S. defenses. However, it would be concerning if an adversary chooses to resolve the issue by adding more warheads to existing launchers or developing MIRVed launchers in the future. As discussed earlier, MIRVed launchers create incentives for preemptive attacks, as the many warheads on the missile could be destroyed in its silo by only one or two U.S. warheads. More heavily MIRVed systems also exacerbate the reciprocal fear of a surprise attack and create first-use pressures on each side, which are toxic for stability. This negative effect on stability holds for the synthesis option as well, as more warheads are loaded onto each missile.

31 Bob Walpole, “Foreign Missile Developments and the Ballistic Missile Threat to the United States Through 2015,” National Intelligence Council, September 1999, archived at https://web.archive.org/web/20250207052249/https://www.dni.gov/files/documents/Foreign%20Missile%20Developments_1999.pdf; and Andrew Sessler et al., *Countermeasures: A Technical Evaluation of the Operational Effectiveness of the Planned US National Missile Defense System* (Washington, DC: Union of Concerned Scientists, 2000), 35–37, <https://drum.lib.umd.edu/items/34c60be7-d34b-4791-bcf5-502e9c55149a>.

32 Laura Grego, “Do Technology Advances Allow Missile Defences to Make Up Ground?,” *Journal of Strategic Studies* 48, no. 2 (February 2025): 465–509, <https://doi.org/10.1080/01402390.2024.2447306>.

33 U.S. Department of Defense, *Military and Security Developments Involving the People’s Republic of China 2024: Annual Report to Congress* (Washington, DC: U.S. Department of Defense, 2024), 62, <https://media.defense.gov/2024/Dec/18/2003615520/-1/-1/0/MILITARY-AND-SECURITY-DEVELOPMENTS-INVOLVING-THE-PEOPLES-REPUBLIC-OF-CHINA-2024.PDF>; and Jacob Mezey, “Russian and Chinese Strategic Missile Defense: Doctrine, Capabilities, and Development,” Atlantic Council, September 10, 2024, <https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/russian-and-chinese-strategic-missile-defense-doctrine-capabilities-and-development/>.

34 Jones, *The Official History*, 214.

35 Herbert F. York, “Multiple-Warhead Missiles,” *Scientific American* 229, no. 5 (November 1973): 24, <https://www.jstor.org/stable/24923239>.

ADVERSARY STRATEGY 2: STAGGERED LAUNCHES

Closely timed or coordinated strikes can severely mitigate the effectiveness of an ABM system. During a strike against the United States, adversaries could launch ICBMs in a particular order to minimize the impact of U.S. defenses and could severely limit the advantage of the multiple kill vehicles in NGIs.

There are many historical antecedents for planning close coordination of a strike. The U.S. Air Force's Strategic Air Command had exquisite timetables and coordination for its various attack plans throughout the Cold War.³⁶ More specifically, in the late 1960s, the United States included an option in the Single Integrated Operational Plan (SIOP) for countering the Moscow ABM system by launching missiles in two closely coordinated waves of Minuteman I/II ICBMs and Polaris sea-launched ballistic missiles (SLBMs).³⁷

In the contemporary context, single-warhead missiles could be fired at the GMD system one after another such that each requires at least one NGI to intercept but must be destroyed before that NGI can attack the next ICBM in the sequence. It would take relatively few missiles to exhaust the NGI magazines, on the order of 10 to 20 depending on the sophistication of their countermeasure package.³⁸ Then the rest of an adversary's missile force could launch unopposed.

This approach incentivizes some portion of an adversary's force to be single-warhead ICBMs, akin to the Small ICBM proposed during the late Cold War.³⁹ A small, mobile missile would be relatively survivable and not particularly useful in a first strike.⁴⁰ If this emphasis on single-warhead ICBMs spreads across the entire land-based leg of an adversary's nuclear forces, it would improve crisis stability, especially if they were mobile and thus more likely to survive a U.S. attack. Even if they were still based in silos, these ICBMs would likely be net neutral for crisis stability relative to existing adversary forces, as their single warhead would not invite preemptive attack in the same way MIRVed silo-based ICBMs do—particularly given the two-on-one targeting that is likely used to plan attacks on hardened silos to account for reliability and accuracy issues.

However, if adversaries combine Strategy 1 with staggered launches and focus on optimizing their arsenals against multiple kill vehicles, they could build a very different force, which might consist of a limited number of single-warhead missiles to be used to exhaust NGIs, with the rest of the land-based force consisting of heavily MIRVed ICBMs. Such an approach would allow the most efficient coverage of an adversary's target set once U.S. interceptors are depleted. They could pace any expansion of the U.S. NGI force by deploying additional single-warhead ICBMs—and with relative financial ease, as the \$100 million NGI is vastly more expensive than either Russia's Topol-M or China's DF-31A, for example.⁴¹ This force would upset stability, making adversaries reliant on heavily MIRVed ICBMs to deliver most of their payloads. Of course, whether this type of force is appealing to

36 Daniel Ellsberg, *The Doomsday Machine: Confessions of a Nuclear War Planner* (London: Bloomsbury, 2017), 97–99.

37 Hans M. Kristensen, Matthew G. McKinzie, and Robert S. Norris, "The Protection Paradox," *Bulletin of the Atomic Scientists* 60, no. 2 (March–April 2004): 66–77, <https://doi.org/10.1080/00963402.2004.11460771>.

38 Some observers have noted that more sophisticated countermeasures packages may demand two NGIs per ICBM, especially if more than one interceptor is assigned to each missile as part of a shoot-look-shoot intercept strategy. See Francis G. Mahon, Punch Moulton, and John Shapland, "Comprehensive Missile Defense Must Be More Than Quality and Quantity," *Breaking Defense*, December 13, 2022, <https://breakingdefense.com/2022/12/comprehensive-missile-defense-must-be-more-than-quality-and-quantity/>.

39 Scowcroft et al., *Report of the President's Commission*, 15.

40 *Ibid.*

41 A Topol-M reportedly cost approximately 400 million rubles in 2008, roughly equivalent to \$24 million as of December 2023. See Igor Moric and Timur Kadyshev, "Forecasting Costs of U.S. Ballistic Missile Defense Against a Major Nuclear Strike," *Defense and Peace Economics* 36, no. 2 (2025): 141–66, <https://doi.org/10.1080/10242694.2024.2396415>.

an adversary depends on its targeting policy and overall attitude toward nuclear warfighting: Does the adversary only want to demonstrate deterrence and strike countervalue targets, or does it want to strike conventional and nuclear military targets along with war-supporting industry? If the former is true, an adversary might favor a Small ICBM–like force, whereas if the latter is correct, it might prefer a mixed force of single-warhead systems accompanied by heavily MIRVed ICBMs.

Staggered launches would leave portions of an adversary’s strategic forces open to U.S. counterattack while launches are underway. MIRVed missiles waiting to attack would be tempting targets as the initial wave of single-warhead ICBMs engage the GMD system. This period of vulnerability contributes to the destabilizing character of this force. It further suggests staggered launches may not be prudent for some adversaries. While Russia’s and China’s large, well-defended interiors make U.S. strikes with conventional weapons difficult to execute during a conflict, North Korea’s small size and inferior air and missile defenses make a prolonged launch window undesirable. However, the United States could choose to preempt the waiting MIRVed missiles with ICBMs or SLBMs, accentuating the destabilizing character of this force, despite its ability to defeat interceptors armed with multiple kill vehicles.

ADVERSARY STRATEGY 3: ATTACK ABM INFRASTRUCTURE

First strikes on portions of the U.S. ABM radars, command and control nodes, or the interceptors themselves would be another way for adversaries to defeat NGIs. Indeed, NGIs dramatically increase the incentives for them to do so. This strategy is more feasible for Russia or China than North Korea given the latter’s limited power projection capabilities and smaller ICBM arsenal. Russia or China could use depressed-trajectory ICBMs or SLBMs, stealthy cruise missiles, or fractional orbital bombardment systems (FOBS) to do so.⁴² Adversaries could even attempt an attack similar to Ukraine’s Operation Spiderweb, using pre-positioned drones armed with explosives to strike ABM infrastructure.⁴³

Some U.S. targeting plans in the late 1960s called for early ICBM and SLBM attacks on Soviet ABM systems; the planned assault would reportedly begin with strikes on radars before turning to Soviet ABM interceptors.⁴⁴ This approach built on the U.S. Strategic Air Command’s tradition of planning to attack Soviet air defenses early in a conflict to open corridors for bombers to strike the Soviet interior.⁴⁵ Similarly, the Soviet Union fielded a variant of the SS-9 ICBM armed with a FOBS in the 1960s in response to planned U.S. ABM deployments.⁴⁶ A FOBS would have allowed it to attack ABM sites from the south, avoiding much of the early warning system of the United States and its allies, and opening the way for the rest of the Soviet strategic forces.

Adversaries could strike the radars supporting the GMD system, such as the Cobra Dane in the Aleutian Islands, the Long-Range Discrimination Radar at Clear Space Force Station in Alaska, the early warning radars at Thule Site J in Greenland and Royal Air Force Fylingdales in England, the

42 Soofer argues it would be easy for Russia to conduct strikes against GMD radars and more difficult, yet still possible, for China to do so. See Robert Soofer, “First, We Will Defend the Homeland: The Case for Homeland Missile Defense,” Atlantic Council, January 4, 2025, <https://www.atlanticcouncil.org/in-depth-research-reports/report/first-we-will-defend-the-homeland-the-case-for-homeland-missile-defense/>.

43 James Marson, Jane Lytvynenko, and Brenna T. Smith, “The Ukrainian Spy Agency Behind the Stunning Strike on Russia’s Bomber Fleet,” *Wall Street Journal*, June 4, 2025, <https://www.wsj.com/world/ukraine-spy-sbu-russia-drone-attack-f78f9713>.

44 Kristensen, McKinzie, and Norris, “Protection Paradox,” 71.

45 Ellsberg, *Doomsday Machine*, 137.

46 Asif A. Siddiqi, “The Soviet Fractional Orbiting Bombardment System (FOBS): A Short Technical History,” *Quest: The History of Spaceflight Quarterly* 7, no. 4 (Spring 2000): 22–32, <https://static1.squarespace.com/static/5ef8124031cfc448b11db32/t/5f1c4647c77c4c27acda0b3a/1595688526845/Siddiqi+FOBS+A+Short+Technical+History+2000.pdf>.

Sea-Based X-Band Radar, and forward-deployed tracking radars. Interceptors are only as capable as the radars that cue and guide them, making this a highly effective strategy, particularly since these systems are generally fragile and vulnerable to blast and nuclear effects. Adversaries need not even physically strike the radars; high-altitude nuclear explosions could “black out” early warning and targeting radars, generating ionized gases that attenuate or block radar waves while producing a variable infrared background able to confound kill-vehicle sensors.⁴⁷ Radar blackout is a long-recognized problem for ABM systems, one that cannot be resolved through the introduction of more kill vehicles.⁴⁸ Attacking other elements of the ABM command and control system such as the In-Flight Interceptor Communication System Data Terminals at Fort Greely, Fort Drum, Vandenberg Space Force Base, and Eareckson Air Station would undermine GMD operations as they relay communications from GMD Fire Control to the interceptors while they are in flight.⁴⁹

However, with the introduction of NGIs, the interceptors themselves become a more tempting target for attack. Since GBIs were deployed, there has been an incentive for adversaries to strike the interceptor silo fields in Fort Greely and Vandenberg, as damaging the interceptors on the ground prevents them from deflecting the rest of a missile force later in an attack. However, while each GBI can only threaten one adversary warhead, making it not particularly threatening on a per-unit basis, the multiple kill vehicles on an NGI dramatically increase the incentives for adversaries to strike first. Now that each interceptor can hold several warheads at risk, the threat they pose to adversary arsenals will expand exponentially. So too will adversary incentives to try to eliminate this capability in the early phases of a conflict. If an adversary waits too long, its capabilities may be too degraded to attempt such a strategy or, if the conflict escalates and the United States strikes first, it could be forced into ragged retaliation against the NGI force, a more imposing proposition than retaliation against GBIs. While it is unclear how many kill vehicles will be mounted on each NGI, the introduction of such a capability significantly expands the incentive for adversaries to strike interceptor silo fields early.

The 2023 Strategic Posture Commission argued that the United States needs expanded air and missile defense capability to protect against limited coercive strikes on critical U.S. targets, such as ballistic missile submarine bases, by adversaries attempting to sever Washington from its allies.⁵⁰ If this argument is true and adversaries are indeed preparing for such strikes, there are few targets more tempting for such an attack than either the Fort Greely silo fields or the GMD-supporting radars. From an adversary perspective, such limited strikes could signal resolve and attempt to shear the United States from its allies in a regional conflict while degrading important U.S. capabilities; from an American perspective, an attack on GMD infrastructure could easily be interpreted as the harbinger of a large-scale nuclear attack on the continental United States. This escalation pathway has existed since the introduction of the GMD system, but the introduction of multiple kill vehicles makes it a more probable one, as adversary incentives to strike these targets are higher.

47 Frederick K. Lamb et al., *Strategic Ballistic Missile Defense: Challenges to Defending the United States* (College Park, MD: American Physical Society, 2025), <https://www.aps.org/publications/reports/strategic-ballistic-missile-defense>; and Grego, “Do Technology Advances Allow?”

48 Hans A. Bethe and Richard L. Garwin, “Anti-Ballistic-Missile Systems,” *Scientific American* 218, no. 3 (March 1968): 21–31, <https://www.scientificamerican.com/article/anti-ballistic-missile-systems/>.

49 Thomas Karako, Ian Williams, and Wes Rumbaugh, *Missile Defense 2020: Next Steps for Defending the Homeland* (Washington, DC: CSIS, 2017), 102. <https://missilethreat.csis.org/missile-defense-2020/>.

50 Creedon et al., *America’s Strategic Posture*, 66.

Such an approach would clearly erode crisis stability between Washington and its adversaries. First, this strategy pushes adversaries to consider strikes on the United States earlier in a conflict, broadening the geographic bounds of regional conflicts and escalating them by introducing homeland attacks. Second, such strikes imply an expanded nuclear dimension for a conflict. Attacks on interceptors or supporting infrastructure would likely be interpreted as a prelude to a larger strike on the United States and encourage reciprocal U.S. actions, including generating strategic nuclear forces or raising their alert level. Third, these strikes would reduce the information available to decisionmakers. Attacks on GMD-supporting radars would degrade overall situational awareness for the United States, removing valuable information and making a crisis or smaller conflict more difficult to control by forcing leaders to make decisions under uncertainty.

FINDINGS, IMPLICATIONS, AND RECOMMENDATIONS

Potential adversary responses to multiple kill vehicles are not uniformly destabilizing. Indeed, oversaturation through countermeasures would likely be stabilizing, as it would reassure the adversary that it could defeat U.S. defenses without increasing the incentives of either side to strike first. Similarly, staggered launches as a tactic are not destabilizing, though the vulnerability they generate by creating a long launch window may be. However, oversaturation by MIRVing and attempting to negate the GMD system through first strikes are both destabilizing.

Barring an adversary shift toward Small ICBM–like land-based forces with many countermeasures, adversary responses to the introduction of multiple kill vehicles on the NGI would reduce crisis stability. The incentives to strike first or build a force structure around heavily MIRVed missiles would increase mutual incentives for each side to escalate in a crisis or during a low-level conflict. When these responses are put into conversation, they tend to become more destabilizing. Adversaries could combine early strikes on ABM infrastructure, a limited single-warhead ICBM force to soak up remaining kill vehicles, and a force of heavily MIRVed ICBMs to cover the rest of their target set to produce a very destabilizing force structure and posture. This synthesis response would by far be the most concerning development for crisis stability.

First strikes against ABM infrastructure are likely the easiest response for adversaries to implement, as they would not require changes to hardware, merely a more forward-leaning approach during a crisis or conflict. Similarly, staggered launches could be easily done given the requisite command and control infrastructure, but optimizing this strategy would likely require either changing the loading of existing ICBM forces or developing new systems. The long lead times required for the latter suggest it would be the most difficult response; instead, both China and Russia, with their pedigrees in developing countermeasures, could upgrade their packages with relative ease, especially compared to the cost to the United States of building additional NGIs.⁵¹

Washington could choose to remove the incentive for adversaries to pursue these responses in the first place. Since the age of the existing GBIs makes it unlikely the NGI program will be canceled, the United States should continue the program without multiple kill vehicles. The NGI will bring other improvements, including reliability and survivability enhancements, thereby modernizing the interceptor force. It would be more prudent to remove the multiple kill vehicles and focus on improving a single kill vehicle with more sophisticated sensors, which would enhance discrimination

51 Walpole, “Foreign Missile Developments”; and Sessler et al., *Countermeasures*, 35–37.

capability and reduce software complexity while adding additional divert capability.⁵² A more capable single kill vehicle would keep the U.S. ABM system relevant for rogue states such as North Korea, which are unlikely to deploy a large force of MIRVed missiles. The added sensitivity of larger sensors would increase the chances of distinguishing decoys from reentry vehicles, the fundamental problem having multiple kill vehicles attempts to address, without worsening crisis stability in the U.S.-Russia or U.S.-China dyads. This alternative would bring down the cost of each interceptor, as kill vehicles are historically the most expensive element. Remaining funds could be used to upgrade kill vehicle sensors, build another array for the Long-Range Discrimination Radar, or address any number of other defense priorities. However, even this more limited deployment may still provoke adversary responses depending on their interpretation of the threat posed by U.S. defenses.

CONCLUSION

The introduction of multiple kill vehicles on the NGI has hardly been discussed from a stability perspective. This piece hopes to prompt a larger discussion about the deterrence implications of higher numbers of kill vehicles in the U.S. ABM program. It is imprudent to suspect adversaries will do nothing in response to U.S. deployments. While it is difficult to know where one is in the action-reaction cycle, as adversaries may have already priced the NGI into their current or future force structures, an examination of some potential reactions suggests NGI deployment will erode crisis stability.

It is possible the introduction of multiple kill vehicles will do for the offense-defense competition what the introduction of MIRVs did for the offense-offense competition of the 1970s: push each side toward larger numbers of weapons postured in ways that exacerbate the risk and consequences of escalation. However, we can take inspiration from Smith's account of the ABM Treaty "controlling technology before it was developed" by placing qualitative controls on weapons.⁵³ While the prospect for a negotiated or informal agreement with adversaries on limiting multiple kill vehicles seems remote, establishing a norm of responsible self-restraint in this area would allow the United States to opt out of a new offense-defense arms race.

52 Rebecca Slayton, *Arguments That Count: Physics, Computing, and Missile Defense, 1949-2012* (Cambridge, MA: Massachusetts Institute of Technology Press, 2013), 204–206, 215.

53 Smith, *Doubletalk*, 367–68.



Effects of Nonnuclear Strategic Weapons on First-Strike Stability

By Colin Levaunt¹

INTRODUCTION

Since the end of the Cold War, there have been significant advancements in nonnuclear strategic weapons (NNSWs), which have the potential to disrupt traditional notions of strategic stability and, more specifically, first-strike stability. These capabilities can be employed to generate or influence the generation of strategic effects, offensively or defensively, and may thus have similar deterrent roles.² This article presents an evaluative framework originally developed at RAND in the late Cold War for evaluating strategic nuclear forces and applies the framework to assess the potential effects of NNSWs on “first-strike stability”—which refers to the ability of both sides in a potential nuclear exchange to absorb a first strike and retain enough weapons to launch a retaliatory second strike, therefore

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- 1 Colin Levaunt is an analyst at the RAND Corporation. The analysis conducted for this report was conducted independently and its conclusions are derived solely by the author and do not reflect those of his employer. The author would like to thank all of those he has been fortunate to have discussions with and learn from through the CSIS Project on Nuclear Issues Nuclear Scholars Initiative.
 - 2 For other definitions and explorations of non-nuclear strategic weapons, see Khuzaima Aftab, “Strategic Non-Nuclear Weapons: The 21st Century Manhattan Project,” DLP Forum, August 1, 2023, <https://www.dlpforum.org/2023/08/01/snnws-21st-century-manhattan-project/>; Fabian Hoffman and William Alberque, *Non-Nuclear Weapons with Strategic Effect* (London: International Institute for Strategic Studies, 2022), <https://www.iiss.org/research-paper/2022/03/non-nuclear-weapons-with-strategic-effect-new-tools-of-warfare/>; James M. Acton, “Escalation through Entanglement: How the Vulnerability of Command-and-Control Systems Raises the Risk of an Inadvertent Nuclear War,” *International Security* 43, no. 1 (Summer 2018): 56–99, https://doi.org/10.1162/isec_a_00320; Tom Sauer, “The Potentially Revolutionary Impact of Emerging and Disruptive Technologies and Strategic Conventional Weapons on the Nuclear Deterrence Debate,” Stockholm International Peace Research Institute, December 2024, <https://www.sipri.org/publications/2024/eu-non-proliferation-and-disarmament-papers/potentially-revolutionary-impact-emerging-and-disruptive-technologies-and-strategic-conventional/>; and Christopher Ford, “Conventional ‘Replacement’ of Nuclear Weapons?,” Hudson Institute, November 17, 2010, <https://www.hudson.org/national-security-defense/conventional-replacement-of-nuclear-weapons->

presenting less pressure to strike first in a crisis.³ However, it should be noted that this is not the only criterion by which strategic forces should be evaluated, especially as greater first-strike stability may allow for greater limited aggression due to the mutual deterrence of full-scale nuclear war.⁴

This chapter assesses three NNSW capability areas.⁵ Offensively, these weapons can enable a more effective first strike by directly attacking an adversary's nuclear forces, thereby reducing the number of targets requiring a nuclear weapon, or by increasing the number of nuclear forces subject to attack. Defensively, NNSWs can increase the survivability of nuclear forces in an adversary first strike by providing strategic defenses or reducing the number of weapons needed to launch a retaliatory second strike.

FIRST-STRIKE STABILITY

To assess the effect of NNSWs on first-strike stability, this paper applies a framework originally developed at RAND in the late Cold War, extending it to allow for the inclusion of nonnuclear strategic weapons.⁶

The framework models the reduction in each side's deployed strategic nuclear weapons in a counterforce first strike, as depicted in "drawdown" curves starting from the top right of each graph shown in Figure 1.⁷ These curves show how many weapons are retained by the defender (and thus are available for a retaliatory second strike against the attacker) and how many weapons are retained by the attacker (and thus are available to continue attacking the defender). The framework then allows for the remaining forces to be assessed against the number of weapons required to achieve each side's objectives. Figure 1 shows notional drawdown curves for the two sides—"Red" and "Blue"—under three hypothetical situations, the red curve representing a Red first strike and the blue curve representing a Blue first strike.⁸

The point in the upper right of each curve represents the initial inventories of weapons of both sides, with Red along the horizontal axis and Blue along the vertical axis. The segments of the curves correspond to attacks on different target classes—in order, ballistic missile submarine (SSBN) ports, strategic bomber bases, mobile intercontinental ballistic missile (ICBM) garrisons, and ICBM silos—and the slope of the segments is determined by the ratio of weapons destroyed to weapons expended. The points in the lower left of each curve represent the remaining weapons for each side following a first strike, which is assessed against the number of weapons the defender must retain

3 Glenn A. Kent and David E. Thaler, *First-Strike Stability: A Methodology for Evaluating Strategic Forces* (Santa Monica, CA: RAND Corporation, 1989), v, <https://www.rand.org/pubs/reports/R3765.html>.

4 Glenn H. Snyder, "Balance of Power and the Balance of Terror," in *Balance of Power*, ed. Paul Seabury (San Francisco, CA: Chandler Publishing Company, 1965), 184–201.

5 These areas were chosen as representative examples of potential capabilities of NNSWs and do not represent any particular real-world capabilities, nor are the representative areas necessarily exhaustive of all potential NNSW capabilities.

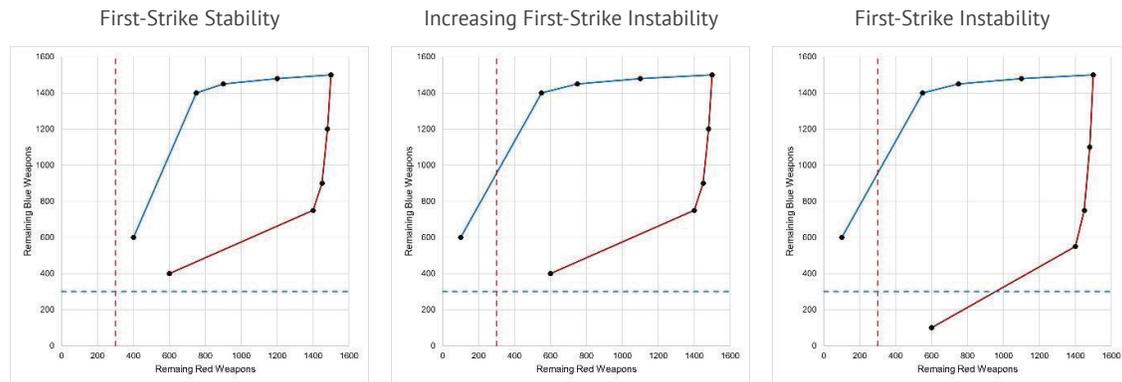
6 For more information on the methodology of first-strike stability, see Glenn A. Kent, Randall J. DeValk, and David E. Thaler, *A Calculus of First-Strike Stability: A Criterion for Evaluating Strategic Forces* (Santa Monica, CA: RAND Corporation, 1988), <https://www.rand.org/pubs/notes/N2526.html>; Kent and Thaler, *First-Strike Stability: A Methodology for Evaluating Strategic Forces*; Glenn A. Kent and David E. Thaler, *First-Strike Stability and Strategic Defenses: Part II of a Methodology for Evaluating Strategic Forces* (Santa Monica, CA: RAND Corporation, 1990), <https://www.rand.org/pubs/reports/R3918.html>; Glenn A. Kent, *Thinking About America's Defense: An Analytic Memoir* (Santa Monica, CA: RAND Corporation, 2008), 73–82, https://www.rand.org/pubs/occasional_papers/OP223.html; and Eric Heginbotham et al., *The U.S.-China Military Scorecard: Forces, Geography, and the Evolving Balance of Power, 1996–2017* (Santa Monica, CA: RAND Corporation, 2015), 285–319, https://www.rand.org/pubs/research_reports/RR392.html.

7 Kent, *Thinking About America's Defense*, 73–82.

8 The use of the terms "nuclear weapons" and "weapons" refers generically to nuclear warheads, so the first-strike stability framework of drawdown curves applied in this analysis does not capture details related to specific warhead delivery systems or warhead characteristics.

to launch a sufficient retaliatory second strike, represented by the vertical (Red) and horizontal (Blue) dashed lines.⁹ The two sides are considered to have “first-strike stability” if the lower left points of each curve remain above and to the right of the dashed lines, representing both sides retaining enough nuclear weapons to retaliate, and less stable if the curves cross the opposite color’s dashed lines, representing one or both sides retaining insufficient weapons for a retaliatory second strike.

Figure 1: Notional Red and Blue Drawdown Curves



Source: Adapted from Kent and Thaler, *First-Strike Stability: A Methodology for Evaluating Strategic Forces*, Figure 2.

To determine the drawdown curves, the model takes as input notional force structures and postures for Red and Blue, as well as notional targeting and weaponing parameters; it then calculates the number of remaining weapons for both Red and Blue as attacker and defender. Importantly, this analysis does not represent high-fidelity modeling and simulation of nuclear exchanges.

NOTIONAL FORCE STRUCTURES AND POSTURES

To eliminate the real-world effects on first-strike stability of different strategic nuclear force structures and postures, this analysis represents Red and Blue symmetrically (see Table 1). “Force structure” represents the quantities of systems, and “posture” represents the alert level of those systems as it affects their survivability (e.g., relocating mobile ICBMs out of garrison, sending SSBNs out to sea, or placing strategic bombers on strip or air alert).¹⁰ For simplicity of analysis, this paper assumes under baseline conditions that forces on alert are not targetable and are thus not subject to attack.

Table 1: Notional Symmetric Strategic Nuclear Forces and Postures for Red and Blue

System	Number	Warheads per System	Total Warheads per System Class	Percentage of Assets on Alert and Not Subject to Attack
Silo-based ICBMs	350	1	350	0
Mobile ICBMs	150	1	150	33
SSBNs/SLBMs	10/15	75/5	750	50

9 The number of weapons the defender must retain is represented as a strict requirement for a sufficient retaliatory second strike for simplicity of analysis. See Kent and Thaler, *First-Strike Stability: A Methodology for Evaluating Strategic Forces*, for an example of rigorous development of a second-strike “requirement” via potential level of damage.

10 In this analysis, both strategic nuclear force structure and posture are held constant to isolate the effects of the NNSW capabilities assessed. However, strategic nuclear force structure and posture significantly affect first-strike stability and are the primary factors assessed in the first-strike stability framework as traditionally applied. See Kent, DeValk, and Thaler, *A Calculus of First-Strike Stability*; Kent and Thaler, *First-Strike Stability: A Methodology for Evaluating Strategic Forces*; and Heginbotham et al., *The U.S.-China Military Scorecard*, 285–319.

System	Number	Warheads per System	Total Warheads per System Class	Percentage of Assets on Alert and Not Subject to Attack
Strategic bombers/ ALCMs	50/5	5/1	250	0
Total			1500	

Source: Author's analysis.

TARGETING AND WEAPONNEERING

Since the framework models counterforce first strikes, the attacker's targets are the defender's strategic nuclear weapons, represented by ICBM silos, mobile ICBM garrisons, SSBN ports, and strategic bomber bases. Similar to force structures and posture, Red and Blue are represented with symmetrical target sets (see Table 2).

Table 2: Notional Target Sets for Red and Blue

Target	Number
ICBM silos	350
Mobile ICBM garrisons	10
SSBN ports	2
Strategic bomber bases	5

Source: Author's analysis.

The number of weapons expended by the attacker and the expected damage, in terms of destroyed defender warheads, are calculated using parameters describing the weapon and target.¹¹

Weaponneering requirements are derived using the following criteria:

1. **Weapon reliability:** The probability that a warhead will arrive at its designated ground zero (DGZ) without malfunction. For simplicity and to maintain consistency with other analysis, both sides' systems are assumed to have 80 percent reliability.¹²
2. **Single-shot probability of kill (SSPK):** The probability that a warhead, assuming it has reached its DGZ, will destroy it, which is a function of target hardness and weapon yield and accuracy.¹³
3. **Terminal single-shot probability of kill (terminal SSPK):** The probability that a warhead will both reach its DGZ and destroy it, which is the product of weapon reliability and SSPK.
4. **Terminal multi-shot probability of kill (terminal MSPK):** The cumulative probability that a DGZ is destroyed when targeted by multiple warheads.
5. **Overall probability of kill (PK):** The probability that a target is destroyed. For point targets (e.g., ICBM silos) consisting of only a single DGZ, this is the same as the SSPK or MSPK.

11 These parameters and the equations used in the calculations were derived and sourced from Heginbotham et al., *The U.S.-China Military Scorecard*, 285–319; and Lynn Etheridge Davis and Warner R. Schilling, "All You Ever Wanted to Know about MIRV and ICBM Calculations but Were Not Cleared to Ask," *Journal of Conflict Resolution* 17, no. 2 (June 1973): 207–42, <https://www.jstor.org/stable/173221>.

12 Heginbotham et al., *The U.S.-China Military Scorecard*, 290.

13 Consistent with the analysis done by Heginbotham et al., it is assumed that the hardness of missile silos is 2,000 psi, 1,000 psi for SSBN port DGZs, and 20 psi for TEL garrison and bomber base DGZs: Heginbotham et al., *The U.S.-China Military Scorecard*, 292.

6. **Confidence level:** The attacker's desired probability that every target in the target set is destroyed. To be consistent with other analysis, both sides' confidence level is set to 80 percent.¹⁴

ANALYSIS

This section assesses the effects of NNSWs on first-strike stability, both offensively and defensively. In all scenarios, Red and Blue have a notional requirement of retaining enough weapons following a first strike to retaliate sufficiently against 200 targets; for this analysis, retaliation is assumed to require 300 weapons under baseline conditions.

BASELINE

Figure 2 depicts the baseline Red and Blue drawdown curves, representing counterforce first strike options for both sides with the notional force structures, postures, and targets from Tables 1 and 2. Since Red and Blue have symmetrical force structure and posture, their respective first strikes are also symmetrical. Additionally, in this model the attacker disarms themselves in attempting to destroy adversary weapons, in particular hardened ICBM silos. In the real world, the attacker would likely not self-disarm but instead withhold the expenditure of additional weapons as the marginal return for striking additional counterforce targets diminishes, thus retaining some proportion of their weapons following a first strike.

In Figure 2, from the top right, indicating the initial inventories of weapons for both sides, the line segments represent, in order:

1. **Strikes on SSBN ports:** Expenditure of 13 weapons and destruction of 335 weapons
2. **Strikes on strategic bomber bases:** Expenditure of 24 weapons and destruction of 239 weapons
3. **Strikes on mobile ICBM garrisons:** Expenditure of 56 weapons and destruction of 98 weapons
4. **Strikes on ICBM silos:** Expenditure of all 1,408 remaining weapons and destruction of 272 weapons. However, as noted above, in the real world the attacker would withhold the expenditure of additional weapons as the marginal return for striking additional counterforce targets diminishes.

In this baseline scenario for first-strike stability between Red and Blue, both sides retain at least 556 weapons after absorbing a first strike, which is much greater than the 300 weapons required to launch a sufficient retaliatory second strike; Red and Blue thus have robust first-strike stability. It should be noted, though, that the predominant proportion (76 percent) of weapons retained after absorbing a first strike are those that were on alert and thus not subject to attack, and the majority (60 percent) of the other weapons retained are silo-based ICBMs and hard target kills.

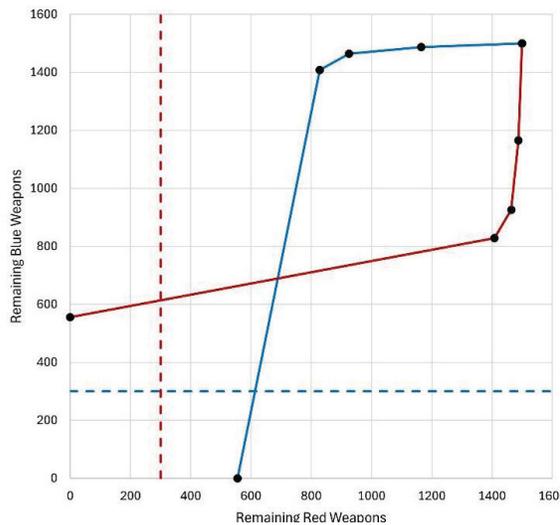
OFFENSIVE NNSW EFFECTS

To assess the potential effects of the offensive NNSW capabilities on first-strike stability, the following two changes are made independently to Red's force structure: Red gains (1) NNSW capability to destroy unhardened counterforce targets, specifically strategic bomber bases and mobile ICBMs; and (2) NNSW capability to target and destroy forces on alert, specifically mobile ICBMs out of garrison and SSBNs out to sea.¹⁵

¹⁴ Ibid., 290.

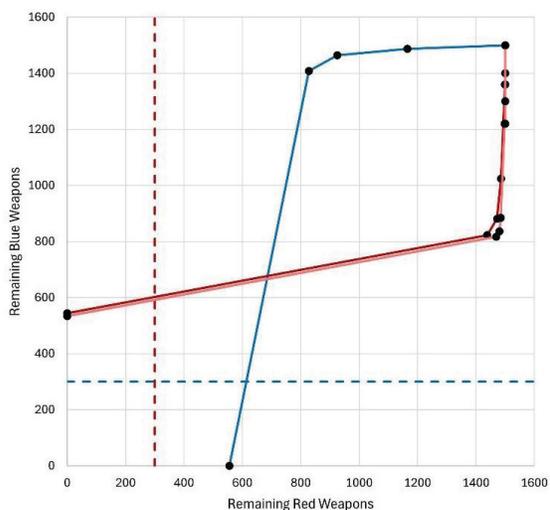
¹⁵ For this analysis, NNSW capability is restricted to striking unhardened targets. However, analysis has been done to suggest that conventional weapons may also be effective against hardened targets: Ryan Snyder, "Assessing the Lethality

Figure 2: Red-Blue Baseline First-Strike Stability



Source: Author's analysis.

Figure 3: Red-Blue First-Strike Stability: Red NNSW Capability to Destroy Strategic Bomber Bases and Mobile ICBM Garrisons



Source: Author's analysis.

Figure 3 depicts the first scenario, in which Red has NNSW capability to destroy strategic bomber bases and mobile ICBM garrisons. Two levels of capability are modeled: The dark red curve represents sufficient NNSW capability for Red to destroy 40 percent of both Blue's strategic bomber bases and mobile ICBM garrisons, and the light red curve represents sufficient NNSW capability for Red to destroy 80 percent of each. With the capability to destroy 40 percent of such targets, Red is able to expend 31 fewer weapons to destroy the same number of Blue's SSBN ports, strategic bomber bases, and mobile ICBM garrisons than in the baseline scenario. With the capability to destroy 80 percent, Red is able to expend 62 fewer weapons to destroy the same set of Blue targets.

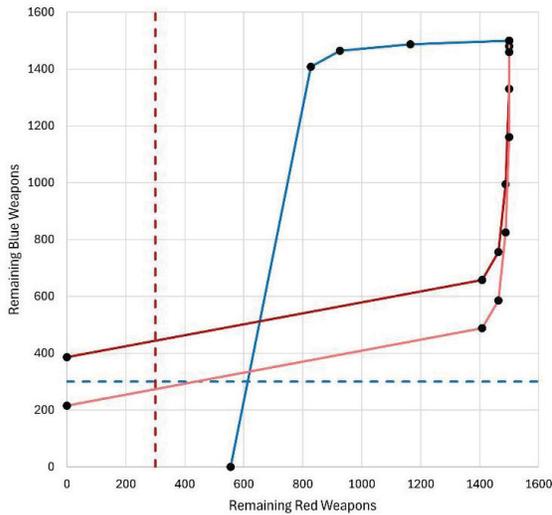
In this scenario, while Red is able to destroy counterforce targets with NNSWs and reduce the number of nuclear weapons expended in a first strike, Blue and Red still retain 544 and 556 weapons, respectively—even in the case with the highest level of Red NNSW capability—after absorbing a first strike from the other. Thus, Red and Blue continue to demonstrate robust first-strike stability.

However, the relative insignificance of the effect of Red's NNSW capability to destroy unhardened counterforce targets is due to Blue's force structure and posture, in particular the small proportion of weapons subject to attack at strategic bomber bases (3.4 percent) and mobile ICBM garrisons (6.7 percent). If a greater proportion of Blue's forces were structured and postured to be on strategic bombers and mobile ICBMs, then the effect of NNSW capability to destroy these targets would be more significant.

of Conventional Weapons against Strategic Missile Silos in the United States, Russia, and China," *Science & Global Security* 32, no. 1–3 (2024): 105–173, <https://doi.org/10.1080/08929882.2024.2393537>). Note that the ability to both target and destroy SSBNs out to sea during a first strike would represent a significant change in capability. For further analysis regarding the effects of such increased capability on first-strike stability, see Kent and Thaler, *First-Strike Stability: A Methodology for Evaluating Strategic Forces*. Analysis also suggests that emerging technologies will be more effective at increasing survivability rather than increasing vulnerability: Tom A. Stefanick, "Undersea Nuclear Forces: Survivability of Chinese, Russian, and US SSBNs," *Journal of Strategic Studies* 48, no. 2 (April 2025): 334–406, <https://doi.org/10.1080/01402390.2025.2454644>.

Alternatively, Blue can mitigate the effects of Red's NNSW capability if a greater proportion of its forces are on alert and thus not subject to attack, whether by nuclear weapons or NNSWs.

Figure 4: Red-Blue First-Strike Stability: Red NNSW Capability to Target and Destroy Mobile ICBMs Out of Garrison and SSBNs Out to Sea



Source: Author's analysis.

Figure 4 depicts the second scenario, in which Red can target and destroy mobile ICBMs out of garrison and SSBNs out to sea. Two levels of capability are modeled: The dark red curve represents sufficient NNSW capability for Red to destroy 40 percent of both Blue's mobile ICBMs out of garrison and its SSBNs out to sea, and the light red curve represents sufficient NNSW capability for Red to destroy 80 percent of each. In the 40 percent case, Red is able to destroy an additional 170 Blue weapons compared to the baseline. In the 80 percent case, Red is able to destroy an additional 340 Blue weapons compared to the baseline.

In this scenario, depending on the level of Red's NNSW capability to target Blue's mobile ICBMs out of garrison and SSBNs out to sea, Blue retains significantly fewer weapons. With the highest level of Red NNSW capability, Blue retains only 216 after absorbing a first strike, below the 300 needed to carry out a retaliatory second strike. Therefore, in this scenario, Red and Blue demonstrate increasing first-strike instability.

This dramatic effect of Red's NNSW capability to target and destroy forces on alert is due significantly to the impact on SSBNs out to sea, four of which are destroyed in the 80 percent case, accounting for the destruction of 20 percent of Blue's total weapons (compared to 2.7 percent of Blue's total weapons destroyed by Red's attacks on mobile ICBMs out of garrison).

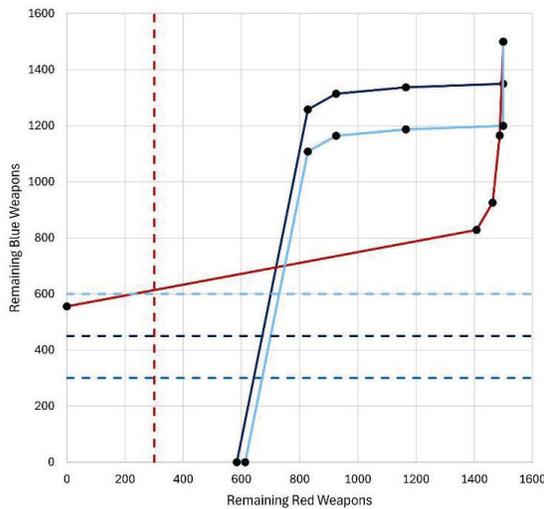
DEFENSIVE NNSW EFFECTS

To assess the potential effects of defensive NNSW capabilities on first-strike stability, the following two changes are made independently to Red's force structure: Red gains (1) NNSW capability to provide strategic defenses; and (2) NNSW capability to destroy retaliatory targets.

Figure 5 depicts the first scenario, in which Red has NNSW capability to defend against Blue's nuclear weapons. Two levels of capability are modeled: The dark blue curve represents sufficient NNSW capability for Red to defend against 150 Blue weapons, and the light blue curve represents sufficient NNSW capability for Red to defend against 300 Blue weapons. With Red having this capability, Blue must expend additional weapons in a first strike to maintain the same level of expected damage as in the baseline scenario. Blue must also retain additional weapons following the absorption of a first strike to launch a sufficient retaliatory second strike, represented by the dark and light blue horizontal dashed lines.

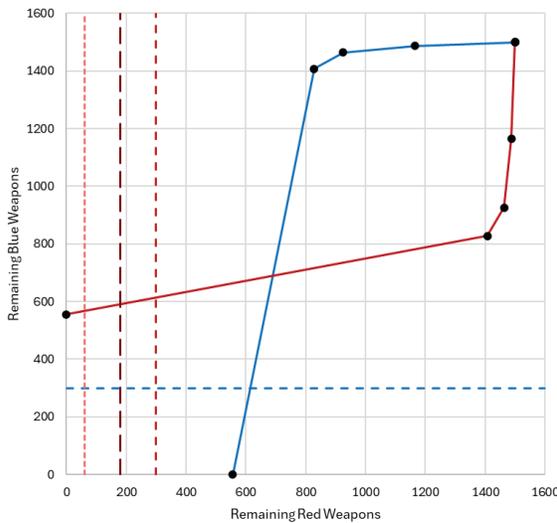
In this scenario, if Red has the NNSW capability to defend against 300 Blue weapons, Blue now has to retain at least 556 weapons to retaliate. Therefore, Red and Blue have increasing first-strike

Figure 5: Red-Blue First-Strike Stability: Red NNSW Capability to Defend Against Blue's Weapons



Source: Author's analysis.

Figure 6: Red-Blue First-Strike Stability: Red NNSW Capability to Destroy Retaliatory Targets



Source: Author's analysis.

instability. While Red's NNSW capability to provide strategic defenses against 300 weapons can defend against 20 percent of Blue's weapons in a first strike, this defense does not significantly affect Blue's expected level of damage against Red, only increasing Red's number of weapons retained following the absorption of a first strike by 38. Thus, the most significant effect on first-strike stability results from Red's NNSW capability to effectively provide strategic defenses.¹⁶

Figure 6 depicts the second scenario, in which Red has NNSW capability to destroy retaliatory targets. Two levels of NNSW capability are modeled: The dark red vertical dashed line represents sufficient NNSW capability for Red to destroy 40 percent of retaliatory targets, and the light red vertical dashed line represents sufficient NNSW capability for Red to destroy 80 percent of retaliatory targets. In the former case, Red must retain 180 weapons following the absorption of a first strike, 120 fewer than in the baseline scenario. In the latter, Red only has to retain 60 weapons, 240 fewer than in the baseline scenario.

Although Red's NNSW capability to destroy retaliatory targets means it can launch a second-strike attack with significantly fewer weapons, Red and Blue still each retain 556 weapons after a first strike. Thus, they continue to have robust first-strike stability. Even if Blue had a more effective first strike in terms of expected damage, first-strike stability would still be robust since Red's retaliatory requirement in terms of weapons is reduced. Therefore, Red's NNSW capability to destroy retaliatory targets increases first-strike stability.

CONCLUSION

While NNSW capabilities can affect first-strike stability, this effect is not necessarily destabilizing. Assessed using the evaluative first-strike stability framework developed by RAND in the late Cold War, NNSWs have the following effects:

16 For further analysis regarding these effects, see Kent and Thaler, *First-Strike Stability and Strategic Defenses*.

- **Directly attacking an adversary's nuclear forces**, thereby reducing the number of targets requiring a nuclear weapon in a first strike, does not have a significant effect on first-strike stability, negatively or positively. However, this observation is due to the force structure and posture of the defender; different force structures and postures could give NNSW capability more impact, potentially resulting in increased first-strike instability.
- **Increasing the number of nuclear forces subject to attack in a first strike** might increase first-strike instability, particularly if these NNSWs are able to target and destroy SSBNs out to sea.
- **Increasing the survivability of nuclear forces by providing strategic defenses** significantly challenges a defender's ability to retain enough nuclear weapons to launch a retaliatory second strike, likely resulting in increased first-strike instability.
- **Reducing the number of nuclear weapons needed to launch a retaliatory second strike following the absorption of a first strike** increases first-strike stability because retaliatory capabilities are maintained even if an adversary has a more effective first strike. Further, this capability may mean fewer nuclear weapons are required to deter first strikes.

However, there may be higher-order effects on first-strike stability, including the compounding effects of different NNSW capabilities and the dynamics emerging from capabilities possessed by both sides. Furthermore, NNSW capabilities, though strategic, do not suffer from the "nuclear taboo" and may thus be perceived as being more "usable," increasing the pressure for them to be used in crises and producing instability. This may be particularly acute at lower echelons of conflict, where there is potential increased propensity to escalate. In addition, NNSW capabilities may similarly suffer from the perception of not being credible and thus not sufficiently affect adversary decisionmaking, potentially limiting deterrence and producing instability. Further analysis is required to understand the dynamics between these effects themselves, as well as their impact on first-strike stability.

As the United States and others develop new capabilities, they should pay special attention to NNSW capabilities and the potential effects they may have on first-strike stability. While the development of NNSW capabilities could be destabilizing, they also have the potential to increase first-strike stability and reduce the number of strategic nuclear weapons required for deterrence.

Adapting to the New Nuclear Age



Illusory Assurance

By Yashar Parsie¹

Nuclear weapons should assure allies that Washington will defend them. The United States maintains *assurance*—which, like deterrence, depends on perceived credibility—as an explicit role for its nuclear forces. Credible assurance, though, can be hard to attain. This paper explores the fundamental reasons why. It begins by reviewing the place of assurance in U.S. nuclear policy and then explains concepts in political psychology that challenge the logic of assurance. The paper ends with a recommendation that policymakers rethink their commitment to assurance.

MIND GAMES

Assurance is defined as giving allies confidence that commitments are credible. Michael Howard introduced the concept into the strategic lexicon in the context of the United States’ pledge to defend allies in NATO during the Cold War: “The American military presence was wanted in Western Europe, not just in the negative role of a deterrent to Soviet aggression, but in the positive role of a reassurance to the West Europeans.” It was “the kind of reassurance a child needs from its parents.”² Nuclear forces are used to make commitments more credible.

Assurance remains an explicit role for U.S. nuclear forces, as reiterated across U.S. strategy documents. The 2024 Nuclear Employment Strategy declared: “The roles of nuclear weapons in United States strategy are to deter strategic attack [and] assure allies and partners.”³ The 2022 Nuclear Posture Review stated: “U.S. nuclear weapons deter aggression [and] assure allies and partners.”⁴ The 2010 Nuclear Posture Review further explained that “a failure of reassurance could lead to a decision by one or more nonnuclear states to seek nuclear deterrents of their own.”⁵ U.S.

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- 1 Yashar Parsie is a member of the Nuclear Scholars Initiative Class of 2025. The views expressed are his own and do not represent any employer.
 - 2 Michael Howard, “Reassurance and Deterrence: Western Defense in the 1980s,” *Foreign Affairs* 61, no. 2 (Winter 1982): 310, <https://doi.org/10.2307/20041437>.
 - 3 U.S. Department of Defense, *Report on the Nuclear Employment Strategy of the United States* (Washington, DC: U.S. Department of Defense, November 2024), 2, <https://media.defense.gov/2024/Nov/15/2003584623/-1/-1/1/REPORT-ON-THE-NUCLEAR-EMPLOYMENT-STRATEGY-OF-THE-UNITED-STATES.PDF>.
 - 4 U.S. Department of Defense, *2022 Nuclear Posture Review* (Washington, DC: U.S. Department of Defense, 2022), 7, <https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.pdf>.
 - 5 U.S. Department of Defense, *2010 Nuclear Posture Review* (Washington, DC: U.S. Department of Defense, 2010), 4, <https://csp.aerospace.org/sites/default/files/2021-08/Nuke%20Posture%20Review%20Apr10.pdf>.

nuclear policy connects assurance to extended deterrence and nonproliferation. By redressing the fear of abandonment, nuclear forces should relieve pressure on allies to proliferate. Like deterrence, assurance is creating a perception to influence behavior. Perceived credibility, then, is crucial to U.S. nuclear policy.

However, credible deterrence is insufficient for credible assurance. The requirements of deterrence and assurance, rather, appear “largely additive and cumulative.”⁶ One does not guarantee the other. Beyond deterrence, the requirements of assurance range from deepening dialogue to developing military capabilities.⁷ In particular, credible assurance may demand specific symbols of commitment.⁸ In the Cold War, for instance, European leaders felt that visibly present nuclear forces were substantially more credible.⁹ Nuclear forces are the wedding ring in a marriage of allies, that symbol of commitment.

Nuclear alliances, however, can be faithless unions. Allies question U.S. commitments and demand special demonstrations of fidelity. As former UK Defense Minister Denis Healey quipped, “it takes only five percent credibility of American retaliation to deter the Russians, but it takes 95 percent credibility to reassure the Europeans.”¹⁰ Assurance asks much more than deterrence, and it depends greatly on words and deeds. The 2023 Strategic Posture Commission warned that “any major changes to U.S. strategic posture, policies, or capabilities will . . . have great effect on Allies’ perceptions and their deterrence and assurance requirements.”¹¹ Preserving credible assurance is both a dominant and delicate task in U.S. nuclear policy.

Policymakers, therefore, make important decisions based on their implications for assurance. In recent years, the need to assure has shaped U.S. nuclear policy, force posture, and defense programs, as the below examples illustrate. Assurance, then, is a consequential role for U.S. nuclear forces.

NO FIRST USE

In 2021, the United States considered adopting a declaratory policy that it would not use nuclear weapons first, known as no first use (NFU). Worries over assurance had earlier discouraged the Obama administration from pursuing NFU.¹² As the Biden administration entertained the idea, critics warned that NFU could “enhance anxieties, dilute assurance, prompt pursuit of other security guarantees, and potentially drive the need for the United States to engage in costly improvements in and expansion of conventional and nonnuclear military capabilities.”¹³ Indeed, the press reported that “U.S. allies from Tokyo to Berlin [were] alarmed. . . . [They] strongly urged Washington not to weaken

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- 6 Clark A. Murdock et al., *Exploring the Nuclear Posture Implications of Deterrence and Assurance: Workshop Proceedings and Key Takeaways* (Washington, DC: CSIS, November 2009), 8, https://csis-website-prod.s3.amazonaws.com/s3fs-public/legacy_files/files/publication/100222_Murdock_NuclearPosture_Print.pdf.
 - 7 Michael O. Wheeler, *The Changing Requirements of Assurance and Extended Deterrence* (Alexandria, VA: Institute for Defense Analyses, July 2010), <https://apps.dtic.mil/sti/tr/pdf/ADA550264.pdf>.
 - 8 Murdock et al., *Exploring the Nuclear Posture Implications*.
 - 9 David S. Yost, “Assurance and US Extended Deterrence in NATO,” *International Affairs* 85, no. 4 (July 2009): 755–80, <https://www.jstor.org/stable/27695089>.
 - 10 Denis Healey, *The Time of My Life* (New York: W.W. Norton, 1989), 243, quoted in Yost, 768.
 - 11 Madelyn R. Creedon et al., *America’s Strategic Posture: The Final Report of the Congressional Commission on the Strategic Posture of the United States* (Alexandria, VA: Institute for Defense Analyses, 2023), 107, <https://www.ida.org/-/media/feature/publications/a/am/americas-strategic-posture/strategic-posture-commission-report.ashx>.
 - 12 Brad Roberts, “Debating Nuclear No-First-Use, Again,” *Survival* 61, no. 3 (2019): 39–56, <https://doi.org/10.1080/00396338.2019.1614788>.
 - 13 William A. Chambers et al., *No-First Use of Nuclear Weapons: A Policy Assessment* (Alexandria, VA: Institute for Defense Analyses, January 2021), 37, <https://www.ida.org/-/media/feature/publications/n/no/no-first-use-of-nuclear-weapons-a-policy-assessment/p-20513.ashx>.

its declaratory policy in way that could embolden China and Russia and reduce the deterrent effect” of its nuclear forces.¹⁴ President Joe Biden ultimately reneged on a campaign promise to restrain U.S. nuclear policy.¹⁵ Whatever its wisdom, Biden’s decision pivoted on allied perceptions of credibility.

WASHINGTON DECLARATION

In 2023, South Korean political leaders mused about pursuing nuclear weapons. The U.S. ally worried that Washington would not promise nuclear attack against North Korea when North Korea could retaliate against the United States.¹⁶ The United States responded with the Washington Declaration in April 2023, bolstering the alliance. It committed to “further enhance the regular visibility of strategic assets to the Korean Peninsula, as evidenced by the upcoming visit of a U.S. nuclear ballistic missile submarine to [South Korea],” as well as deepened military cooperation.¹⁷ As nuclear policy official Vipin Narang explained, “these efforts . . . assure allies by demonstrating our resolve to defend them with the full range of U.S. capabilities, including nuclear.”¹⁸ In just one year, an apparent crisis of confidence compelled Washington to act. The United States reset the alliance on terms more assuring to South Korea, including the posture of its nuclear forces

NUCLEAR-ARMED SEA-LAUNCHED CRUISE MISSILE

Since 2023, the Department of Defense has been developing a nuclear-armed sea-launched cruise missile (SLCM-N). When Washington announced the retirement of a similar capability in 2010, policymakers found that “Japanese officials expressed serious concern,” given the growing threat from China. That was because this capability “provides an additional measure of assurance, especially for Indo-Pacific allies. . . . If allies perceive that plausible U.S. response options were limited or unavailable, then they might choose to develop and field their own nuclear weapons,” a blow to nonproliferation.¹⁹ Indeed, analysts note, “when the United States has attempted to make up” for that capability, “the solutions have been temporary and not responsive to the core of allied concerns—potentially inspiring allies to seek their own security arrangements and capabilities, including nuclear weapons.”²⁰ However many motives there may be for the SLCM-N, a prominent one is restoring allied confidence. U.S. defense programs tie in directly with assurance, which itself ties into nonproliferation.

Allies seek assurance, and the United States endeavors to assure them. Assurance is a demanding role for U.S. nuclear forces. Policymakers make consequential decisions about nuclear policy, posture, and programs over allied perceptions. By evincing genuine commitment, allies should perceive the United

14 Demetri Sevastopulo and Felicia Schwartz, “Biden Avoids Radical Shift in New Nuclear Weapons Policy,” *Financial Times*, October 27, 2022, <https://www.ft.com/content/05b71f9a-0fbb-4be5-821a-d2d50b611005>.

15 Joseph R. Biden, Jr., “Why America Must Lead Again: Rescuing U.S. Foreign Policy After Trump,” *Foreign Affairs* 99, no. 2 (March/April 2020): 75, <https://www.jstor.org/stable/26892665>.

16 Bruce Bennett et al., *Options for Strengthening ROK Nuclear Assurance* (Santa Monica, CA: RAND Corporation, 2023), 31, https://www.rand.org/pubs/research_reports/RRA2612-1.html.

17 U.S. Embassy & Consulate in the Republic of Korea, “Washington Declaration,” press release, April 27, 2023, <https://kr.usembassy.gov/042723-washington-declaration/>.

18 “Nuclear Threats and the Role of Allies: A Conversation with Acting Assistant Secretary Vipin Narang,” (public event, CSIS, Washington, DC, August 1, 2024), <https://www.csis.org/analysis/nuclear-threats-and-role-allies-conversation-acting-assistant-secretary-vipin-narang>.

19 John R. Harvey and Rob Soofer, *Strengthening Deterrence with SLCM-N* (Washington, DC: Atlantic Council, November 2022), 6, <https://www.atlanticcouncil.org/wp-content/uploads/2022/11/Strengthening-Deterrence-with-SLCM-N.pdf>.

20 Matthew R. Costlow and Keith B. Payne, “TLAM-N and SLCM-N: Lessons for Extended Deterrence and Assuring Allies,” National Institute for Public Policy, *Information Series*, No. 567, November 15, 2023, 8, https://nipp.org/information_series/matthew-r-costlow-and-keith-b-payne-tlam-n-and-slcm-n-lessons-for-extended-deterrence-and-assuring-allies-no-567-november-15-2023/.

States as credible. U.S. credibility should allay their insecurity, and they should eschew their own nuclear weapons. The logic of assurance is intuitive; it is also wishful.

CHASING SHADOWS

Psychology shapes how statesmen think. Defining interests, taking risks, understanding behavior, and making predictions are matters of the mind. As Robert Jervis puts it, they are “the product of the way our brains are ‘hard wired’ to process information.”²¹ Psychology finds pathologies in how actors make choices that deviate from rational expectations. There has been much attention to psychology and deterrence but less so to the psychology of assurance. This paper draws from political psychology to explain why assurance is hard.

The psychology of states shapes their perceptions. Because assurance is intended to influence perceived credibility, psychological processes are central. Political psychology sets at least four expectations of allies, explored below. First, allies will perceive competing interests between each other. Second, allies will be preoccupied by the fear of abandonment. Third, allies will discount attempts to assure them. Fourth, allies will neglect to update their assessments of credibility. Together, these expectations mean that allies cannot take commitments as credible. Assurance is hard, in other words, because allies are hardwired to doubt it.

EGOISM

Social identity theory finds that groups see themselves differently, and that difference suffices for conflict. Suppose two strangers, ego and alter, meet in the state of nature. They have no conflicting identity, competing interests, or common history. Yet their interaction produces an identity opposed to the other; ego is not alter and alter is not ego. To categorize, compare, and create an identity is necessary for cognition. As psychological experiments have found, it is also sufficient for conflict. Jonathan Mercer concludes: “Once we assume that we have two states, we can assume each will compete against the other regardless of the other’s behavior. . . . ego and alter are predisposed to compete against each other prior to interacting with one another.”²² There is an in-group and out-group from the start. Competition is automatic. This competition manifests in the preference for *relative gains* over *absolute gains* between groups. Ego prefers doing better than alter to both doing well. Social identity theory departs from the rational preference for absolute gains. Forming social identities is the micro-foundation of self-help in anarchy.²³ Allies prioritize their own security over the alliance. After all, states that make common cause are not conjoined twins. Egoism suggests that allies will perceive their interests as distinct from each other. This perception colors the credibility of assurance.

LOSS AVERSION

Prospect theory presents an alternative model of risky decisionmaking. Mercer points out that “how we frame information should not influence our judgement, but it does.”²⁴ Prospect theory finds that people make choices based on gains and losses relative to some reference point, often the status quo, rather than absolute outcomes.²⁵ Although rational actors should calculate their expected

21 Robert Jervis, “Introduction: Approach and Assumptions,” in *Psychology and Deterrence*, eds. Jervis et al. (Baltimore, MD: Johns Hopkins University Press, 1989), 4.

22 Jonathan Mercer, “Anarchy and Identity,” *International Organization* 49, no. 2 (Spring 1995): 246–7, <https://www.jstor.org/stable/2706971>.

23 *Ibid.*, 251.

24 Jonathan Mercer, “Prospect Theory and Political Science,” *Annual Review of Political Science* 8, no. 1 (2005): 1, <https://doi.org/10.1146/annurev.polisci.8.082103.104911>.

25 Jack S. Levy, “An Introduction to Prospect Theory,” *Political Psychology* 13, no. 2 (June 1992): 171–86, <https://www.jstor.org/>

utility, people feel losses more than they do equivalent gains. That is because “negative things are weighed more heavily psychologically than positive things.”²⁶ People care more about losing what they possess than gaining what they covet—what is called *loss aversion*. For example, most people prefer a 90 percent probability of losing \$1,000 to the certainty of losing \$900, despite no change in expected utility.²⁷ Prospect theory expects people to make bigger gambles to stave off terrible losses, “risks they would be unlikely to take if they were in a domain of gain.”²⁸ In international politics, allies receive extended deterrence, so they will be paranoid about losing it. This psychological instinct supports a security imperative, to prevent abandonment. “Alliances are never absolutely firm,” Glenn Snyder notes, adding “the fear of being abandoned by one’s ally is ever-present.”²⁹ Allies jealously guard their security commitments, and they will take extraordinary measures to prevent abandonment. For instance, that Japan expressed more concern about weakening deterrence than provoking China over SLCM-N is no surprise. States are more sensitive to their perceived threats than distant allies. Assurance will struggle to overcome these perceptions.

ATTRIBUTION

The fundamental attribution error holds that people explain behavior differently, and those explanations are biased. When someone cuts you off in traffic, you might think they are a jerk—not that they are rushing to the hospital. The former is a *dispositional* explanation; it relates to character. The latter is a *situational* explanation; it relates to circumstance. “People interpret behavior,” Mercer explains, “in either situational or dispositional terms depending on the desirability of that behavior. More specifically, observers use dispositional attributions to explain an out-group’s undesirable behavior, and situational attributions to explain an out-group’s desirable behavior.”³⁰ In other words, people explain behavior based on whether they like it. This bias leads them to dismiss good deeds and remember bad ones. The fundamental attribution error suggests a perverse tendency, Mercer finds: “While adversaries can get reputations for having resolve, they rarely get reputations for lacking resolve; and while allies can get reputations for lacking resolve, they rarely get reputations for having resolve.”³¹ For assurance to work, states must expect allies to behave in the future as they did in the past. Yet the fundamental attribution error predicts that allies will dismiss assurance as situational—a product of circumstance—and remember the failure to assure as dispositional—a reflection of character. These biases limit how much goodwill a loyal friend can get.

ASSIMILATION

Psychology predicts that people will struggle to change their first impressions. That is because they *assimilate* new information to preexisting beliefs. The need for cognitive consistency leads them to mold contrary information to fit their expectations. Rational actors should adjust their beliefs to new information, a process known as *Bayesian updating*, but people anchor those beliefs to process that information. For example, U.S. intelligence became more confident in assessing Saddam Hussein’s weapons of mass destruction program before the Iraq War, despite receiving more ambiguous

stable/3791677. See also Robert Jervis, “The Political Implications of Loss Aversion,” *Political Psychology* 13, no. 2 (1992): 187–204, <https://doi.org/10.2307/3791678>.

26 Rose McDermott, “Prospect Theory in Political Science: Gains and Losses from the First Decade,” *Political Psychology* 25, no. 2 (April 2004): 291, <https://www.jstor.org/stable/3792565>.

27 Daniel Kahneman, *Thinking, Fast and Slow* (New York: Farrar, Straus, and Giroux, 2011), 280–1.

28 Mercer, “Prospect Theory and Political Science,” 2.

29 Glenn Snyder, “The Security Dilemma in Alliance Politics,” *World Politics* 36, no. 4 (July 1984): 466, <https://doi.org/10.2307/2010183>.

30 Jonathan Mercer, *Reputation and International Politics* (New York: Cornell University Press, 1996), 9.

31 *Ibid.*, 10.

information.³² Jervis notes the endurance of these mental images: “It is striking that people often preserve their images in the face of what seems in retrospect to be clear evidence to the contrary. We ignore information that does not fit, twist it so that it confirms, or at least does not contradict, our beliefs, and deny its validity. Confirming evidence by contrast is quickly and accurately noted.”³³ By cognitive necessity, forming expectations limits one’s ability to make inferences. In drawing them, one assigns weight based on what one expects to see. This explains the tendency to observe behavior that confirms one’s beliefs and overlook behavior that challenges them. Indeed, one might say that believing is seeing. The tendency to assimilate suggests that states fail to favorably revise their assessments of credibility. Allies will observe signs of perfidy but overlook acts of loyalty. When they presume a commitment incredible, they will prove most difficult to credibly assure.

The psychology of states makes credible assurance hard. Four tendencies work against it. First is egoism. Social identity theory suggests that even allies perceive themselves as different groups. Allies are competitive, preferring to do better than the other, and put their interests above the alliance. Second is loss aversion. Prospect theory finds that people hate losing more than they like winning. It suggests that allies will be paranoid about security commitments and take big risks to prevent abandonment. Cognitive patterns make matters worse. Third is the fundamental attribution error. States will attribute assurance by their ally to circumstance, not character. Allies rarely get credit for being faithful but often criticism for being fickle. Fourth is the tendency to assimilate. People tend to fit information to their beliefs rather than revise those beliefs. This suggests that states will fail to update their assessments of credibility. When they think a commitment incredible, it will be hard to change their minds.

France in the Cold War shows these pathologies at work. Charles de Gaulle is a useful caricature because he behaved just as political psychologists would expect. The general possessed “a certain idea of France” and conceived French interests as very different from his U.S. ally. In the early 1960s, he went so far as to tell the Kennedy administration to keep out of European affairs, “only bringing its weight to bear in case of necessity.”³⁴ France, instead, should lead. De Gaulle wanted to have his cake and eat it too, benefiting from U.S. security but dictating its Europe policy. Of course, de Gaulle had always doubted U.S. credibility. His worldview rested on the belief that great powers act in their national interests. The United States would never trade New York for Paris.³⁵ As the U.S.-Soviet nuclear balance narrowed, de Gaulle felt it too close for comfort. “No one alive can say whether, where, how, and to what extent American nuclear arms would be used in the defense of Europe,” he declared.³⁶ Washington recognized the crisis of confidence. Yet when the United States adopted the limited-war strategy of *flexible response* to improve its credibility, de Gaulle was unmoved. Though U.S. capability to defend France increased, the shift revealed that extended deterrence was never fully credible.³⁷ In fact, de Gaulle concluded that the new strategy was another good reason for France to take matters into its own hands.³⁸

32 Robert Jervis, *Why Intelligence Fails: Lessons from the Iranian Revolution and the Iraq War* (New York: Cornell University Press, 2010), 190.

33 Robert Jervis, *Perception and Misperception in International Politics* (Princeton, NJ: Princeton University Press, 1976), 143.

34 Marc Trachtenberg, *A Constructed Peace: The Making of the European Settlement, 1945–1963* (Princeton, NJ: Princeton University Press, 1999), 338

35 Phillip H. Gordon, *A Certain Idea of France: French Security Policy and the Gaullist Legacy* (Princeton, NJ: Princeton University Press, 1993), 44.

36 Quoted in *ibid.*, 48.

37 *Ibid.*, 46.

38 *Ibid.*, 54.

France's nuclear destiny is perhaps overdetermined. But it highlights the trouble with assuring allies. De Gaulle worried most about French interests. He was willing to take risks to secure them. He thought the U.S. security commitment was incredible from the start. And he doubled down after the United States tried to improve its credibility. U.S. commitments were never credible, and the United States would soon be more vulnerable. So, de Gaulle remained convinced that nuclear weapons were his best bet. For assurance to work, allies must recognize evidence of commitment, revise their assessment of credibility, and relax their need for security. Yet they are not hard-wired to think this way. Psychology suggests that assurance can be ephemeral, if not illusory.

STRATEGIC THINKING

How should the United States approach assurance? U.S. policymakers give assurance a prominent place in U.S. nuclear policy, and they make important decisions about nuclear forces out of concern for it. Yet psychology uncovers a chronic challenge of alliance politics. Allies are prone to distrust security commitments and predisposed to doubt assurances. That is why credible assurance is hard to come by. Policymakers, then, should rethink their commitment to it. Washington should be more modest in influencing the perceptions of U.S. allies. After all, allies fear for their security because they inhabit a world of power politics. Since assuring them otherwise will be hard, policymakers must be wary of trying too hard.

First, U.S. nuclear policy should relegate the role of assurance. Deterrence is the less ambitious but more important mission. The United States can rely on nuclear forces mostly to deter attacks—including on allies—and win wars if deterrence fails. Lowering the need to assure would relieve a burden on U.S. nuclear forces. The focus would be on getting deterrence right. Second, policymakers should scrutinize options for improving U.S. nuclear posture or programs. To be sure, these policy options may promise benefits to both deterrence and assurance. But seeming to benefit assurance alone is no good reason. Policymakers should do what makes for a more credible nuclear deterrent. Finally, Washington should accept that it cannot always keep its allies happy. It should promote true partnership, not parenting. In approaching assurance, policymakers would best embrace a certain realism: to change what they can, accept what they cannot, and seek the wisdom to know the difference.³⁹

39 Robert McAfee Brown, "Introduction," in *The Essential Reinhold Niebuhr: Selected Essays and Addresses*, ed. Brown (New Haven, CT: Yale University Press, 1986), xxiv.



A Nuclear Iran

Exploring Saudi Arabia's Courses of Action and U.S. Response Strategies

By Clara Sherwood¹

INTRODUCTION

The challenge posed by a nuclear Iran is long-standing. For decades, global leaders have wrestled with the difficult choice between negotiating imperfect agreements or taking military action against Iran's nuclear program. This issue remains urgent.

A crisis involving a nuclear-capable Iran could escalate at any moment. In the wake of the June 2025 U.S. strikes on Iranian nuclear facilities, there has been a pause to reflect and openly debate potential responses before the situation reignites or intensifies. Given that initial intelligence assessments indicate the Iranian nuclear program survived to some degree, the conundrum of a nuclear-capable Iran is far from resolved and persists as a pressing concern.

Discussions about a nuclear Iran and its hedging strategy dominate regional concerns, traditionally overshadowing broader debates on the future nuclear landscape. While the United States has signaled a desire to reduce its regional presence, an Iranian nuclear capability could reconfigure not just regional security structures but also the broader balance of international power. If Washington miscalculates, nuclear dominoes could topple across the Middle East, dragging the United States back into a volatile arena of nuclear brinkmanship.

The intention of this piece is to stimulate thinking and outline potential options, but not to advocate for a particular U.S. course of action. Past U.S. policy in the Middle East illustrates the dangers of adopting overly simplistic binary frameworks for understanding regional order, especially in a context where unintended consequences often shape outcomes. Against the backdrop of U.S. entry into the

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Israel-Iran conflict, Saudi Arabia's growing role as a diplomatic powerhouse, and a fiscally focused U.S. foreign policy, this paper examines the implications of a nuclear Iran through the lens of Saudi Arabia's nuclear-related policy options and the significance for U.S. policy. If Iran develops a nuclear weapon, the United States will need to focus on Saudi Arabia's response, as it will be critical to regional stability and the future of the global nonproliferation regime.

EVOLVING MIDDLE EAST SECURITY DYNAMICS

The Middle East's political landscape remains stochastic, shaped by key developments such as the ongoing conflict between Israel and Iran, a geopolitical pivot from the Levant to the Gulf, and the growing assertiveness of nonstate actors. Despite an emerging pattern of multialignment among regional states, the United States remains the Middle East's leading security patron, a position that seems unlikely to be challenged in the foreseeable future.²

U.S. President Donald Trump confronts an Iranian regime that, while growing increasingly isolated and weakened in terms of domestic legitimacy, is moving closer to developing nuclear weapons (notwithstanding the June 2025 air strikes against Iranian nuclear facilities). As Michael Singh aptly notes, "As the Iranian regime gets weaker in conventional terms, the allure of acquiring nuclear weapons grows."³

Concerns over Iran's nuclear ambitions elicit discussions about the risks of regional nuclear proliferation. Many nuclear and regional experts argue that a nuclear-capable Iran could prompt a cascading reaction, with countries such as Saudi Arabia, Egypt, and Turkey seeking their own nuclear capabilities. Although experts have long assumed this scenario to be the most likely outcome, it deserves scrutiny and deeper analysis. In the absence of explicit nuclear guarantees, the debate continues over how the United States should shape its deterrence posture in the event Iran crosses the nuclear threshold and how best to assure U.S. regional partners.

Should Iran obtain nuclear weapons and the capability to deliver them, the Middle East's security balance would shift dramatically. Some immediate risks could include an existential threat to Israel; Iranian domination of the Strait of Hormuz and related Gulf sea lanes; endangerment of deployed U.S. military forces, allies, and partners in the Persian Gulf; Iranian control of Gulf oil production; and the further empowerment of terrorist groups. Collectively, these developments would deepen the region's nuclear shadows and jeopardize U.S. and allied interests at a time when Washington is already managing a two-nuclear-peer world.

SAUDI ARABIA'S POLICY, DRIVERS, AND NUCLEAR-RELATED POLICY OPTIONS

To truly understand the viability of U.S. policy options, policymakers will need to consider how Saudi Arabia approaches nonproliferation and nuclear concepts. Without consideration for the monarchy's strategic multialignment approach to foreign policy and its guiding domestic transformation, any U.S. strategy risks misjudging the kingdom's incentives, red lines, and long-term nuclear ambitions.

2 Jennifer Kavanagh and Frederic Wehrey, "The Multialigned Middle East," *Foreign Affairs*, July 17, 2023, <https://www.foreignaffairs.com/united-states/multialigned-middle-east-china-influence>.

3 Michael Singh, "Policy Steps to Prevent a Nuclear Iran," Washington Institute for Near East Policy, January 28, 2025, <https://www.washingtoninstitute.org/policy-analysis/policy-steps-prevent-nuclear-iran>.

The United States and Saudi Arabia share a special bilateral relationship dating back to President Franklin Roosevelt's famous meeting in the Suez Canal with the country's founder, King Ibn Saud. President Trump, by making Saudi Arabia the first planned foreign trip of his second term, signaled that he intends to continue bolstering the relationship through financial and diplomatic deals.⁴

Officially, Saudi Arabia maintains a policy against a domestic nuclear weapons program. The kingdom acceded to the Nuclear Non-Proliferation Treaty (NPT) in 1988, and experts on Saudi defense policy agreed in 2004 that "nuclear weapons are not on the Kingdom's strategic agenda."⁵ At the time, Saudi officials privately noted, "If and when Iran acknowledges having, or is discovered to have, actual nuclear warheads, Saudi Arabia would feel compelled to acquire a deterrent stockpile."⁶

Decades later, Saudi Arabia's tipping point appears closer than ever. Crown Prince Mohammed bin Salman, also known as MBS, has publicly confirmed multiple times that Saudi Arabia will seek a nuclear arsenal if Iran develops one. Public opinion is behind him, with recent polls indicating a majority of the population supports the country having access to nuclear weapons, further suggesting a potential shift in Saudi Arabia's status as a nuclear-weapon-free state.⁷

Saudi Arabia's nuclear policy will likely be shaped by a combination of legitimate national security concerns, confidence in U.S. security assurances, and strategic regional and global influence objectives. The kingdom's security outlook is primarily contoured by concerns over Iran's nuclear ambitions and the broader balance of power in the Gulf. In addition to nuclear competition, Riyadh is acutely focused on the Strait of Hormuz, through which a significant share of the world's oil exports pass. Control or disruption of this vital choke point by a nuclear-armed Iran would have dire implications for Saudi economic stability.⁸

Arguably, Saudi Arabia's main concern in the case of a nuclear-armed Iran would be its new capability to use nuclear weapons as a "screen" behind which the country could engage in aggressive behavior. With a nuclear deterrent, Iran would have the ability to carry out international military policy and operations while dissuading conventional or unconventional retaliation from Arab Gulf states.

These concerns are further amplified by the perceived retrenchment of U.S. and broader Western influence in the Gulf, especially regarding regional security guarantees.⁹ Saudi Arabia views U.S. involvement in the region as critical to counterbalancing Iran, but arguably, Riyadh remains skeptical that Washington will ensure its security. The lack of a substantial U.S. response to the 2019 Iranian attack on Saudi oil facilities in Abqaiq and Khurais presumably further prompted Saudi exploration of alternative defense options.¹⁰ Editorials by Gulf academics openly raise concerns about U.S. reliability and illustrate Gulf Cooperation Council (GCC) reservations about U.S.

4 "Fact Sheet: President Donald J. Trump Secures Historic \$600 Billion Investment Commitment in Saudi Arabia," The White House, May 13, 2025, <https://www.whitehouse.gov/fact-sheets/2025/05/fact-sheet-president-donald-j-trump-secures-historic-600-billion-investment-commitment-in-saudi-arabia/>.

5 Thomas W. Lippman, "Saudi Arabia: The Calculations of Uncertainty," in *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices*, eds. Kurt M. Campbell, Robert J. Einhorn, and Mitchell B. Reiss (Washington, DC: Brookings Institution Press, 2004), 118, <http://www.jstor.org/stable/10.7864/j.ctt1vjqtvtv.10>.

6 Ibid., 129.

7 Rafael Loss, "Living in a Nuclear-Curious World: America's Weakening Grip on Non-Proliferation," European Council on Foreign Relations, February 13, 2024, <https://ecfr.eu/article/living-in-a-nuclear-curious-world-americas-weakening-grip-on-non-proliferation/>.

8 Mark Doyle, "A Nuclear-Armed Iran and US Extended Deterrence in the Gulf," *Strategic Assessment* 16, no. 3 (2013): 47–56, https://www.inss.org.il/strategic_assessment/a-nuclear-armed-iran-and-us-extended-deterrence-in-the-gulf/.

9 Tobias Borck, Darya Dolzikova, and Jack Senogles, *Chain Reactions: The Iranian Nuclear Programme and Gulf Security Dynamics* (London: RUSI, 2022), <https://static.rusi.org/338-Iran-GCC.pdf>.

10 Ibid.

abilities to provide security guarantees, particularly given the decline of regional U.S. unipolarity. President Trump's "inability or unwillingness to stop Israel's attack" on Qatar in September 2025 probably further fueled apprehension.¹¹

However, the November 2025 U.S.-Saudi Defense Agreement and President Trump's intention to designate the country as a "major non-NATO ally" renewed MBS's "confidence in the US commitment to his country's security."¹² In the context of a nuclear-capable Iran, Saudi Arabia would likely push for even more extensive assurances or take additional steps to protect itself. Although some have suggested that "hypothetically, the United States could deploy naval assets with a nuclear component to the Persian Gulf or Red Sea to act as a credible deterrent," such measures may not be sufficient to satisfy the kingdom's long-term security concerns.¹³

Furthermore, while Saudi Arabia remains an absolute monarchy, it must contend with domestic opinion and the optics of high-profile U.S. military engagement. Riyadh has traditionally resisted hosting permanent U.S. bases, largely due to pressure from the Wahhabi religious establishment. Today, as Wahhabi influence wanes, MBS must navigate the views of the highly nationalistic youth population he has cultivated when weighing deepening U.S.-Saudi military ties.

Saudi Arabia is increasingly attentive to how its regional posture intersects with global prestige as it plays a more prominent role in international diplomacy. While reputation is not the country's primary driver, political image remains an important consideration. Politics aside, Saudi Arabia is now spending "trillions of its oil dollars developing an economy built on tourism, high tech, and clean energy."¹⁴ The kingdom's economic progress toward achieving Saudi Vision 2030 goals could be undermined by an Iran on the verge of a nuclear bomb or by the increased likelihood of Iranian armament.¹⁵

If Iran acquires nuclear weapons, Saudi Arabia will likely feel compelled not only to protect its own population but also to act as a regional guarantor of security for neighboring states. It will be worried about the emergence of a new regional hegemony since Iran would be able to break international isolation, extend its influence, and assert dominance in the Gulf. Saudi Arabia would be at a strategic crossroads with no ideal options for U.S. foreign policy and national security priorities.

Saudi Arabia's decisionmaking is not a black box. The ambitious MBS is motivated by a grand vision for Saudi Arabia to be a major economic, diplomatic, and military player on a global scale. Karen Elliott House, in a biography on the crown prince, states that Saudi Arabia's foreign policy is a tool for achieving domestic prosperity and argues that MBS's primary goal is "to make Saudi Arabia the power center of the Middle East."¹⁶

U.S. policymakers must understand the drivers of the kingdom's foreign policy for U.S. foreign policy to be effective. While Saudi Arabia would likely evaluate a range of strategic responses to a

11 April Longley Alley and Abdulkhaleq Abdulla, "After Israel's Strike on Qatar, a Strategic Shift," *The Hill*, October 20, 2025, <https://thehill.com/opinion/international/5560909-gulf-states-israel-threat-response/>.

12 Gordon Gray, "From 'Pariah' to Power Player: MBS' Triumphant Washington Comeback," *National Security Journal*, November 20, 2025, <https://nationalsecurityjournal.org/from-pariah-to-power-player-mbs-triumphant-washington-comeback/>.

13 Asmeret Asghedom et al., *The Nuclear Future of the Middle East: Workshop Summary* (Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, May 2024), 15, <https://cgsr.llnl.gov/sites/cgsr/files/2024-08/2024-05-nuclear-future-of-the-middle-east-workshop-summary.pdf>.

14 Karen Elliott House, *The Man Who Would Be King: Mohammed bin Salman and the Transformation of Saudi Arabia* (New York: Harper, 2025), 193.

15 *Ibid.*, 193.

16 *Ibid.*, 162–65.

nuclear Iran, this paper focuses on two primary pathways: the pursuit of a domestic nuclear weapons capability and the option of seeking a U.S. extended deterrence guarantee.

SCENARIO 1: A NUCLEAR SAUDI ARABIA

Saudi Arabia might deem nuclear self-reliance the country's only plausible course of action and seek to develop an independent Saudi nuclear deterrent. While traditional tools of deterrence and assurance could satisfy other regional actors like Egypt and Turkey, they might not dissuade Riyadh. For Saudi Arabia, the stakes are existential. In the case of a nuclear Saudi Arabia, the United States would need to consider how to mitigate risk, prevent a Middle Eastern nuclear arms race, preserve the NPT and nonproliferation regime, consider how Saudi proliferation impacts arms control goals with China and Russia, and prevent further proliferation cascades in the region.

First, U.S. policy toward Saudi Arabia could shift its focus from nonproliferation to risk management. Drawing on Bill Burns's logic, the United States cannot solve every threat to its interests, but it can manage threats at an acceptable cost if disciplined about priorities and mindful of limits.¹⁷

One goal could be to address the nature of Saudi nuclearization by keeping it as transparent, safeguarded, and restrained as possible, rather than attempting to block it altogether. Counterproliferation efforts could backfire, drive the effort underground, or push Saudi Arabia toward a different nuclear power like China or Pakistan. After all, Saudi Arabia recently strengthened its strategic relationship with nuclear-capable Pakistan through a Strategic Mutual Defense Agreement.¹⁸ Riyadh and Islamabad are only 2,600 miles apart, and "it is widely assumed that in extremis the kingdom can procure nuclear weapons from Pakistan."¹⁹ Saudi Arabia might view Pakistan's acquisition of nuclear weapons as an example of successful nuclear deterrence near a regional adversary. Despite heightened tensions and a prolonged arms race throughout the 1970s and beyond, there is a perception that nuclear deterrence had perhaps been successful and even stabilizing in Pakistan's case for independence.

This India-Pakistan example underscores a difficult truth and "dirty needle" conundrum: While nuclear proliferation is undesirable, it may become a reality that the international community is forced to manage rather than prevent outright. The issue of Saudi nuclearization offers a critical question: Would enforcing safety and security measures on an emerging nuclear program be viewed as condoning the establishment of a program? The relative stability in South Asia should not be seen as an exact model to emulate, especially given the unique regional dynamics of the Middle East, where the potential for proxy conflicts, state fragility, and the absence of confidence-building measures could make nuclear competition far more volatile.

Some speculate that upon developing nuclear capability, Saudi Arabia might not employ passive deterrence but instead look to be more assertive in already developed situations, such as in Iraq, Yemen, Lebanon, and Syria. Forceful military actions could raise the risks of escalation and miscalculation, particularly in already fragile security environments. Furthermore, scholars argue that Iran and Saudi Arabia could face the "stability-instability paradox," where nuclear weapons deter

17 William J. Burns, "An End to Magical Thinking in the Middle East," Carnegie Endowment for International Peace, December 8, 2019, <https://carnegieendowment.org/posts/2019/12/an-end-to-magical-thinking-in-the-middle-east?lang=en>.

18 Naade Ali and Marvin G. Weinbaum, "Pakistan's Strategic Defense Pact with Saudi Arabia: A New Security Architecture in the Wider Middle East," Middle East Institute, October 8, 2025, <https://mei.edu/publications/pakistans-strategic-defense-pact-saudi-arabia-new-security-architecture-wider-middle>.

19 House, *The Man Who Would Be King*, 194.

large-scale conflict but can also encourage lower-level provocations and mistrust.²⁰ Should Iran proceed with enriching uranium to weapons-grade levels, Saudi Arabia might see developing its own nuclear capability as a way to create strategic balance.²¹ However, possessing a nuclear deterrent does not guarantee that Iran would adopt a less aggressive foreign policy or refrain from regional confrontation. The United States would likely need to expend significant political and military capital to prevent these flash points from spiraling out of control.

U.S. policymakers will also need to consider the different shapes a Saudi program could take when forming risk management strategies. While the Saudi political appetite for a nuclear capability might be met with the existence of a nuclear weapon, a credible Saudi deterrent could also necessitate the development of sophisticated supporting systems, as well as credible delivery capabilities. However, it is also possible that proliferation in Saudi Arabia and Iran would not mirror proliferation in North Korea. Policymakers might need to break free from the wisdom that a “credible deterrent” requires missile delivery systems. Would a warhead on a tanker shipped to a foreign port have the same deterrent and escalatory effects? Literature assumes that Saudi Arabia will emulate past proliferation cases, but is this certain? These questions illustrate the layers of complication shrouding policymakers’ navigation of Saudi nuclearization.

Second, in the event of Saudi nuclearization, the NPT might either collapse or become effectively irrelevant. Such a development might provide some states with an excuse, incentive, or pretext to develop their own capabilities and abandon the treaty.²² The larger nonproliferation regime supported by the NPT would be severely damaged and require leadership from the United States and other nations to continue diplomatic engagement, reinforce international norms against proliferation, and perhaps even reform aspects of the treaty to address contemporary security concerns.

For the NPT to retain relevance and credibility, the United States would likely need to offer an extremely positive version of the NPT, outlining a U.S. commitment to implement all three pillars of the NPT, including the often-neglected Article VI on disarmament. Without a positive version, maintaining the buy-in of NPT member states will be extremely difficult. In the event of escalating nuclear tensions in the Middle East with the looming context of two nuclear peer adversaries, serious U.S. advocacy for self-disarmament appears politically and strategically unlikely. This is not a diplomatic balancing act that policymakers will be eager to navigate.

Third, should Saudi Arabia develop a nuclear weapon, experts note that Iranian leaders would “likely respond by increasing the number of nuclear weapons in their arsenal, the accuracy of their delivery systems, and the variety of their launch platforms.”²³ Preventing an Iranian-Saudi nuclear arms race could prove extremely challenging, with few immediate tools available to Washington beyond targeted export controls on critical parts for nuclear weapons and their delivery systems.

Fourth, a shift toward Saudi nuclear self-reliance could significantly undermine the existing U.S.-led security framework in the Middle East. If the United States fails to provide credible and enduring

20 Daniel Byman, Doreen Horschig, and Elizabeth Kos, “Will Saudi Arabia Get the Bomb?,” *Foreign Affairs*, May 6, 2024, <https://www.foreignaffairs.com/saudi-arabia/will-saudi-arabia-get-bomb>.

21 Ibid.

22 Jamie Kwong, *Bargaining Short of the Bomb: A Strategy for Preventing Iranian NPT Withdrawal* (Washington, DC: Carnegie Endowment for International Peace, April 2025), https://carnegie-production-assets.s3.amazonaws.com/static/files/Kwong_Iran%20NPT%20withdraw.pdf.

23 Bradley Bowman, *Chain Reaction: Avoiding a Nuclear Arms Race in the Middle East* (Washington, DC: GPO, February 2008), <https://www.govinfo.gov/content/pkg/CPRT-110SPRT39674/html/CPRT-110SPRT39674.htm>.

security guarantees, Saudi Arabia may deepen ties with rival powers like China or Russia, seeking new partnerships to support their new program and compensate for newly perceived vulnerabilities. This pivot could dilute long-standing defense cooperation with the United States, create fractures in multilateral security arrangements such as the GCC, and encourage rival powers to assert greater influence in the region. Over time, a nuclear Saudi Arabia could accelerate a broader realignment of power in the Middle East, complicating U.S. strategic objectives and potentially increasing the risk of miscalculation or arms races in an already volatile environment. Furthermore, a Saudi move toward nuclear self-reliance could complicate U.S. arms control objectives with China and Russia in countless ways, such as by reshaping regional deterrence dynamics, adding complexity to bilateral or multilateral arms control talks, encouraging great power opportunism, breaking down nonproliferation architecture, and destabilizing a nuclear equilibrium that could lead Russia and China to justify further expanding and modernizing their arsenals.

Finally, the United States would need to respond immediately to assure allies and partners in the region that proliferation and development of their own nuclear programs are not viable courses of action, possibly using credible security commitments and counterproliferation strategies. If Iran becomes nuclear capable, a range of factors will affect whether other Middle Eastern countries choose to pursue nuclear weapons. These include their assessments of Iran's regional behavior, their perception of the shifting conventional military balance, the degree of confidence they place in U.S. security guarantees, their expectations about international reactions to any pursuit of nuclear weapons or latent capabilities, and finally whether they have the technical expertise, infrastructure, and financial resources necessary to develop facilities or nuclear weapons.

A nuclear-armed Saudi Arabia would represent a profound shift in the Middle East's strategic landscape—one that carries serious implications for regional stability, the global nonproliferation regime, and U.S. strategic interests. U.S. freedom of action would be complicated and restricted, and a freshly emboldened Saudi Arabia could even force the United States to intervene in a crisis. While the ideal outcome in a nuclear Iran scenario, arguably, remains preventing further proliferation, the United States may need to prepare for a reality in which Saudi nuclearization cannot be fully deterred and instead must be carefully managed.

SCENARIO 2: SAUDI ARABIA SEEKING EXTENDED DETERRENCE GUARANTEES

Saudi Arabia could seek a U.S. extended deterrent guarantee instead of establishing its own nuclear program if it deems a link to the U.S. arsenal is preferable to developing its own credible minimum deterrent. After all, developing a nuclear weapons capability is a complex and resource-intensive endeavor that demands significant national commitment, political determination, and public backing over an extended period.

As Dr. Jennifer Bradley notes, although the terms “extended deterrence” and “assurance” are often used interchangeably, they serve different functions: “Extended deterrence is directed at influencing adversaries to prevent attacks on allies, while assurance is directed at convincing allies of U.S. commitment to their defense. Just as deterrence is a cognitive function in the mind of the adversary, assurance is a cognitive function in the mind of the ally.”²⁴

24 Jennifer Bradley, “Preventing the Nuclear Jungle: Extended Deterrence, Assurance, and Nonproliferation,” *Joint Force Quarterly* 112, no. 1 (2024): 32, <https://digitalcommons.ndu.edu/joint-force-quarterly/vol112/iss1/10>.

This distinction is fundamental in a region where perceptions of U.S. reliability vary widely. Assuming there is U.S. domestic political will and congressional support in this situation, the United States would need to consider the credibility and structure of potential extended deterrence commitments, the distinct assurance needs of Saudi Arabia and other allies, and the strategic, diplomatic, and operational risks associated with an extended deterrence guarantee in such an unpredictable region.

The Middle East likely presents the most challenging extended deterrence environment the United States has ever operated in. Experts believe extended deterrence in the region could take the form of bilateral commitments, multilateral commitments, or ambiguous commitments.²⁵ The primary goals of U.S. extended deterrence would likely be, first, to deter Iran from using or threatening to use nuclear weapons against its neighbors and, second, to reassure friends and allies of their safety. In particular, Iranian threats include nuclear missile attacks, nuclear terrorism, conventional military attacks, political coercion, and conventional terrorism.

First, while extending U.S. nuclear deterrence to Saudi Arabia may be feasible in theory, its practical implementation faces significant challenges. Assurance to Saudi Arabia will be effective only if grounded in proper assessments of Riyadh's values, primary drivers, and security needs. Press reports cite discussions between Saudi and U.S. officials regarding possible mutual defense agreements in the context of Saudi-Israel normalization.²⁶ In the context of a nuclear Iran, achieving results would become more urgent. Saudi Arabia would likely require robust forms of reassurance, such as formal defense commitments, enhanced arms sales, and integrated missile defense cooperation, to view extended deterrence as a viable and enduring alternative to developing its own domestic nuclear program.

In providing an extended deterrent to the Middle East, the United States would not likely base nuclear weapons in the Middle East, and Arab countries would not likely accept the deployment of U.S. weapons within their borders. A nuanced and pragmatic approach to extended deterrence and assurance for allies would be essential in shaping effective policy and preventing regional nuclear cascades in the case of a nuclear Iran. As M. Elaine Bunn aptly states, "Just as deterrence and dissuasion require tailoring, so too does assurance."²⁷ A one-size-fits-all security approach will be insufficient in a nuclear Iran scenario.

Instead of blanket regional commitments, a more sustainable policy could prioritize tailored assurance rooted in an understanding of each country's motivations for nuclear acquisition. Egypt and Turkey are motivated by security concerns but also by domestic politics and international norms.²⁸ Saudi Arabia is primarily motivated by security concerns and will likely perceive an Iranian nuclear capability as an existential threat. However, unlike Egypt or Turkey, Saudi Arabia might not be dissuaded by a formal U.S. defense pact or nuclear umbrella alone, especially given questions about the credibility of U.S. commitments after years of perceived retrenchment.

The GCC as an institution will likely perceive a nuclear Iran as a direct threat to vital interests. Its threat perception might lead it to seek U.S. security guarantees or a guarantee from Saudi Arabia,

25 Asghedom et al., *Nuclear Future*.

26 Christopher M. Blanchard, *Saudi Arabia: Background and U.S. Relations*, CRS Report No. RL33533 (Washington, DC: Congressional Research Service, October 2, 2023), <https://www.congress.gov/crs-product/RL33533>.

27 M. Elaine Bunn, "Can Deterrence Be Tailored?," *Strategic Forum*, January 2007, 2, <https://digitalcommons.ndu.edu/cgi/view-content.cgi?article=1087&context=strategic-forums>.

28 Asghedom et al., *Nuclear Future*.

prompting the United States to consider the shape of its extended deterrence commitment to the region. Would the extended deterrent guarantee take the shape of the North Atlantic Treaty Organization (NATO), an alliance of many states with forward deployment of nonstrategic nuclear weapons and nuclear sharing? Or would the model be East Asia, where U.S. commitments are structured to be separate bilateral defense agreements? Would only Saudi Arabia receive this deterrent and not other states? What about the United Arab Emirates and Qatar? The Gulf presents a complex geopolitical and geographical environment that would likely require a new extended deterrence architecture. In a two-nuclear-peer world, would adding the Middle East to the mix overextend U.S. forces to the point where they may not be credible? Simply put, these are not easy questions to answer.

EXTENDED DETERRENCE RESERVATIONS

The nascent debate over potential U.S. extended deterrence in the Middle East remains active and unresolved. Some experts argue the most effective posture would be one of strategic ambiguity, deliberately leaving unclear the conditions under which the United States might respond with nuclear force to Iranian aggression.²⁹ While potentially advantageous for the United States, this ambiguity may not provide sufficient reassurance to countries like Saudi Arabia, potentially pushing them toward nuclear development.

Proponents of extended deterrence argue that extending deterrence to allies and partners in the region would deter Iran from armed aggression “against certain U.S. allies and partners in the Middle East,” prevent Iranian coercion, prevent or constrain an Israeli-Iranian nuclear arms race, and prevent further nuclear proliferation.³⁰ Given the absence of alternative security guarantors, it is likely that the United States alone has the capability and credibility to provide such assurances.³¹

Conversely, the opposition to extending U.S. nuclear deterrence commitments to regional allies and partners highlights overextension of U.S. resources, the insufficient U.S. stake in the security of its Middle Eastern partners to justify extending a nuclear deterrent, the risk of entanglement and reliability of partners, and fundamental differences between Middle Eastern political systems and the democratic allies that traditionally fall under the U.S. nuclear umbrella.³²

The nuclear future of the Middle East will be shaped by a combination of Iranian and Saudi decisions, regional dynamics, and the U.S. ability to craft a deterrence and assurance strategy that is both credible and customized. Success will require not just military capabilities but also diplomatic agility, cultural awareness, and strategic clarity. However, effective U.S. extended deterrence cooperation between Saudi Arabia and the United States will ultimately hinge on the degree to which Saudi Arabia is prepared to accept the terms.

29 Greg Weaver and Asmeret Asghedom, “Chapter 12: The Limited Prospects for U.S. Extended Deterrence in the Middle East,” in *The Nuclear Future of the Middle East*, ed. Asmeret Asghedom (Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, January 2025), 180, https://cgsr.llnl.gov/sites/cgsr/files/2025-01/occasional-paper-nuclear-middle-east_0.pdf.

30 *Ibid.*, 169.

31 Asghedom et al., *Nuclear Future*.

32 Greg Weaver and Asmeret Asghedom, “The Limited Prospects for U.S. Extended Deterrence in the Middle East,” in *The Nuclear Future of the Middle East* (Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, January 2025), 171, https://cgsr.llnl.gov/sites/cgsr/files/2025-01/occasional-paper-nuclear-middle-east_0.pdf.

SCENARIO 3: A DEAL THAT KICKS THE CAN DOWN THE ROAD

It is entirely possible that the United States could broker an agreement that prevents Iranian and Saudi proliferation. The U.S. administration could continue addressing its key criticisms of the Joint Comprehensive Plan of Action (JCPOA) by negotiating a new deal with Iran that not only curtails Tehran's domestic uranium enrichment and ballistic missile development but also limits its ability to fund regional proxy groups.³³ The success of the administration's negotiations with Iran could help avert a scenario in which Saudi Arabia must decide between initiating its own nuclear program and seeking a U.S. security umbrella that could disrupt regional stability. Given President Trump's relationship with MBS and his demonstrated interest in the Gulf countries, the administration could have a unique opportunity to engage Saudi decisionmaking in moments of crisis.

POLICY IMPLICATIONS

This analysis underscores the need for a more nuanced understanding of Saudi Arabia's policy options in the context of a nuclear Iran and their implications for the United States. The traditional approach to Middle Eastern nuclear policy, often characterized by an inhibition strategy that focuses solely on preventing the spread of nuclear weapons, has become insufficient in the face of evolving regional dynamics.

Neither Saudi nuclearization nor extending a deterrent is ideal for U.S. interests, as both would likely heighten regional instability and complicate efforts to prevent nuclear proliferation in the Middle East. As former U.S. Ambassador Ryan Crocker cautions, U.S. policymakers must remain aware of the law of unintended consequences, recognize the limitations of U.S. power, and avoid entering strategic frameworks that may prove as dangerous to exit as they are to enter.³⁴

Saudi Arabia's response to a nuclear Iran would be critical in determining the trajectory of nuclear proliferation in the Middle East and shaping the future regional security architecture. If the United States miscalculates or fails to engage effectively, the repercussions could extend far beyond the Middle East, potentially reshaping the global balance of power and certainly undermining the credibility of the international nonproliferation regime.

33 Raphael S. Cohen, "The Revenge of the JCPOA," RAND, May 5, 2025, <https://www.rand.org/pubs/commentary/2025/05/the-revenge-of-the-jcpoa.html>.

34 "Ryan Crocker: Beware of Unintended Consequences," *American Interest*, July 30, 2012, <https://www.the-american-interest.com/2012/07/30/ryan-crocker-beware-of-unintended-consequences/>.



Exploring Nuclear Sufficiency Through a Tabletop Exercise

By Sarah Stevenson¹

EXECUTIVE SUMMARY

The emerging two-nuclear-peer threat environment increases the difficulty of deterrence and, should deterrence fail, the achievement of U.S. objectives. In response to this challenge, the 2023 Strategic Posture Commission concluded that the ongoing U.S. nuclear modernization Program of Record (POR) is necessary but insufficient. Despite this warning, the report did not define what capability insufficiencies exist, particularly considering the planned introduction of the B-21 stealth bomber and Long-Range Standoff (LRSO) weapon for penetrating advanced air defenses, and now the nuclear-armed sea-launch cruise missile (SLCM-N) for regional contingencies. Subsequent studies have proposed new theater nuclear capabilities, but the potential impact of these systems on crisis decisionmaking remains largely unexplored.

The study described in this paper helped fill a practical and conceptual gap by using a tabletop exercise (TTX) to assess specific insufficiencies, evaluate their impacts, and explore potential mitigation options. The TTX was set in a Taiwan contingency, with the scenario drop-off occurring at the conflict's first nuclear use: a Chinese low-yield detonation in the Philippine Sea that damaged U.S. maritime assets and caused U.S. force casualties. Four teams representing U.S. Strategic Command (USSTRATCOM) planning cells were tasked with developing nuclear response options under presidential guidance. The teams operated with different theater nuclear force capability sets. All four teams had the modernization POR, including B-21s, LRSOs, and SLCM-Ns in limited numbers. Two of the four teams were also provided a ground-launched system and an air-delivered nuclear antiship capability in theater.

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During the TTX, perceptions of credibility, proportionality, and escalation management shaped response development decisions. Players gravitated toward proportional-plus responses that imposed costs while avoiding uncontrolled escalation. Their ability to shape these choices depended heavily on how they interpreted Chinese intent and perception. Teams worried that striking the mainland with nuclear weapons would invite retaliation against U.S. or allied territory. In addition, the teams doubted that a demonstration strike would restore deterrence. In practice, teams favored operationally relevant but limited responses, such as striking Chinese carrier groups or artificial islands, provided participants had confidence in defeating those targets with their available nuclear capabilities.

The teams' confidence in achieving their desired military effects hinged largely on the theater nuclear force attributes of penetrability, survivability, and the ability to hold a range of targets at risk. Teams without a nuclear antiship capability expressed uncertainty about their ability to defeat mobile maritime targets, which reduced the teams' flexibility and forced consideration of less desired targets. Systems perceived as more likely to reach defended targets, such as standoff delivery, gave players greater confidence that their limited nuclear responses would have the desired military effects while still preserving follow-on options. The ground-launched system, frequently highlighted in recent analyses, was not used by either of the two teams that had access to this capability in the TTX.² The terminal guidance of the ground-launched capability was not specified, so players may not have perceived it to be as tailored to respond in kind against mobile maritime targets as the antiship capability.

While players had greater confidence in achieving their desired military effects, they were not confident that their courses of action (COAs) would have the desired cognitive effect of decisively influencing the adversary's decision calculus. Their debates over COAs underscored the importance of understanding the adversary's perspective, including the cultural and political significance of certain target sets, when assessing whether a strike would restore deterrence after limited nuclear use.

Additionally, across teams, players consistently desired conventional response options to augment or offset the ability of the nuclear options to penetrate and hold their desired targets at risk. Because the TTX design constrained players to nuclear-only response options, the lack of ability to provide conventional support to nuclear operations was perhaps more limiting than the lack of certain nuclear capabilities themselves. While the result of exercise design, this desire for conventional options to complement nuclear ones highlights the importance of integrating conventional and nuclear planning.

Looking ahead, future TTXs need to probe a wider range of scenarios, force postures, and capability attributes. They should examine the role of conventional support to nuclear operations, test deterrence, and escalation dynamics through successive exercise turns, and should incorporate adversary and U.S. allied teams. Together, these efforts can contribute to determining what might constitute a "sufficient" nuclear posture for the emerging two-nuclear-peer threat environment. Answering the question of sufficiency will require balancing nuclear and conventional tools,

2 Chris Andrews and Justin Anderson, *China's Theater-Range, Dual-Capable Delivery Systems: Integrated Deterrence and Risk Reduction Approaches to Counter a Growing Threat* (Washington, DC: National Defense University, August 2024), https://inss.ndu.edu/Portals/82/HDTRA1344728_NDU%20INSS%20CSWMD_TECREP_unclass_Final.pdf; Robert Peters, *A Nuclear Posture Review for the Next Administration: Building the Nuclear Arsenal of the 21st Century* (Washington, DC: Heritage Foundation, July 30, 2024), <https://www.heritage.org/defense/report/nuclear-posture-review-the-next-administration-building-the-nuclear-arsenal-the-21st>; Brad Roberts et al., *China's Emergence as a Second Nuclear Peer: Implications for U.S. Nuclear Deterrence Strategy, CGSR Study Group Report* (Livermore, CA: Lawrence Livermore National Laboratory, March 2023), https://cgsr.llnl.gov/sites/cgsr/files/2024-08/CGSR_Two_Peer_230314.pdf; and Greg Weaver, *The Imperative of Augmenting U.S. Theater Nuclear Forces: An Examination of Alternatives* (Washington, DC: Atlantic Council, April 11, 2025), <https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/the-imperative-of-augmenting-us-theater-nuclear-forces/>.

offensive and defensive systems, and securing institutional buy-in. Short-format TTXs like the one discussed here provide a valuable way to raise the “nuclear IQ” across a broader community, stress test assumptions, and better understand the decision space.³

THE EVOLVING NUCLEAR THREAT ENVIRONMENT

The United States and its allies and partners are entering what many describe as a new nuclear age.⁴ This marks a clear break from the more cooperative post–Cold War era, when Washington and Moscow worked together to reduce their arsenals and U.S. attention centered on rogue states and terrorism. The post-2010 security environment is increasingly shaped by multiple nuclear-armed adversaries, the erosion of arms control, and growing ties among rivals.

China’s ongoing strategic breakout represents a central shift in the evolving nuclear threat picture.⁵ Since 2020, Beijing has expanded from around 200 to more than 600 deliverable warheads and is on track to exceed 1,000 by 2030.⁶ For the first time, two nations—Russia and China—could field nuclear arsenals on par with the United States. China’s force composition, described as “designed to break U.S. strategy,” includes new shorter-range, lower-yield systems for regional employment and hundreds of new silos for land-based intercontinental ballistic missiles (ICBMs), maintained at higher readiness levels than in the past.⁷ The rapid expansion of China’s ICBM silo force, in particular, indicates progress toward establishing its “early-warning counterstrike” posture designed to improve the survivability and responsiveness of its nuclear forces.⁸ These developments have raised doubts about Beijing’s long-standing no-first-use policy and suggest movement toward a more flexible nuclear strategy.

Meanwhile, U.S.-Russia strategic stability dialogue has deteriorated, and Moscow has leaned heavily on nuclear threats for coercion during its war in Ukraine.⁹ As of 2025, Russia fields roughly 1,550 deployed strategic warheads and 2,000 non-strategic weapons, the latter of which are unconstrained by treaty obligations.¹⁰ Russia’s purported suspension of New START in 2023 halted the treaty’s remaining cooperative measures.¹¹ Absent a successor, New START’s scheduled 2026 expiration would

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- 3 Thomas Buchanan, “Project Atom 2024 - CSIS PONI keynote,” speech, November 20, 2024, CSIS, Washington, D.C., <https://www.stratcom.mil/Media/Speeches/Article/3976019/project-atom-2024-csis-poni-keynote/>; and Jill Hruby, “NNSA’s Journey: Achievements and Future Challenges,” *NucleCast*, podcast, January 7, 2025, <https://rss.com/podcasts/nuclecast-podcast/1828710/>.
 - 4 Ankit Panda, *The New Nuclear Age: At the Precipice of Armageddon* (Cambridge, UK: Polity Press, 2025); Brad Roberts, “The Next Chapter in U.S. Nuclear Policy,” *Washington Quarterly* 47, no. 2 (Summer 2024): 7–21, <https://doi.org/10.1080/0163660X.2024.2364529>; and Vipin Narang and Pranay Vaddi, “How to Survive the New Nuclear Age,” *Foreign Affairs* 104, no. 4 (June, 2025), <https://www.foreignaffairs.com/united-states/how-survive-new-nuclear-age-narang-vaddi>.
 - 5 U.S. Strategic Command and U.S. Space Command SASC Testimony, *Before the U.S. Senate Armed Services Committee*, 117th Cong. (March 9, 2022), <https://www.stratcom.mil/Media/Speeches/Article/2960836/us-strategic-command-and-us-space-command-sasc-testimony/>.
 - 6 U.S. Department of Defense, *Military and Security Developments Involving the People’s Republic of China, 2024: Annual Report to Congress* (Washington, DC: U.S. Department of Defense, December 18, 2024), <https://media.defense.gov/2024/Dec/18/2003615520/-1/-1/0/MILITARY-AND-SECURITY-DEVELOPMENTS-INVOLVING-THE-PEOPLES-REPUBLIC-OF-CHINA-2024.PDF>.
 - 7 Narang and Vaddi, “How to Survive the New Nuclear Age.”
 - 8 U.S. Department of Defense, *Military and Security Developments Involving the People’s Republic of China 2024*.
 - 9 Anya L. Fink, “Russia’s Nuclear Weapons,” Congressional Research Service, IF12672, updated May 22, 2025, <https://www.congress.gov/crs-product/IF12672>.
 - 10 *Before the Subcommittee on Strategic Forces, Senate Armed Services Committee*, 119th Cong. (March 26, 2025) (statement of General Anthony J. Cotton, Commander, United States Strategic Command), https://www.armed-services.senate.gov/imo/media/doc/testimony_of_general_anthony_jcotton2.pdf#page=18.
 - 11 U.S. Department of State, *2023 Report to Congress on Implementation of the New START Treaty* (Washington, D: U.S. Department of State, 2024), <https://www.state.gov/bureau-of-arms-control-deterrence-and-stability/releases/2024/01/2023-report-to-congress-on-implementation-of-the-new-start-treaty/>; and Christopher Ashley Ford, “Russian Arms Control Compliance and the Challenge of the Next Agreement,” remarks on June 23, 2020, Council on Foreign Relations, Washington, D.C.,

end bilateral limits on Russia's strategic arsenal for the first time in decades. Russia continues to modernize its forces and pursue destabilizing new systems, including potential space-based nuclear weapons.¹² Since Russia's initial invasion in 2022, nuclear signaling has become a persistent feature of the conflict in Ukraine, raising concern that others, including China and North Korea, may view such tactics as a viable tool for shaping regional conflicts and deterring Western intervention.¹³

Other nuclear-armed states also contribute to a more complex threat environment. North Korea, for example, has steadily expanded its arsenal while defying testing norms, fueling regional escalation concerns and reinforcing opinions in South Korea, where public polling shows growing support for an independent nuclear capability.¹⁴ Iran has posed additional regional challenges and has further eroded confidence in the Nuclear Nonproliferation Treaty (NPT), which has long underpinned the global nuclear order but now faces strain from instances of noncompliance.¹⁵ These challenges to norms are compounded by Russia's unprecedented targeting of an active civil nuclear power plant in Ukraine, alongside recent U.S. and Israeli strikes on nuclear facilities in Iran, demonstrating how nuclear risks are increasingly entangled in regional wars.¹⁶

Adding to these challenges are growing transactional ties among nuclear-armed states. China and Russia in particular have expanded defense cooperation, while Iran and North Korea have both provided direct support to Russia's war in Ukraine.¹⁷ These relationships increase the risk of overlapping crises across theaters, complicating deterrence, escalation management, and crisis stability for the United States and its allies.

transcript available at <https://2017-2021.state.gov/Russian-Arms-Control-Compliance-and-the-Challenge-of-the-Next-Agreement/>.

12 Fink, "Russia's Nuclear Weapons."

13 Anya L. Fink, "Russia's Nuclear and Coercive Signaling During the War in Ukraine," Congressional Research Service, IN12464, November 26, 2024, <https://www.congress.gov/crs-product/IN12464>.

14 Lami Kim, "Will South Korea's Nuclear Ambitions Subside in the Next Five Years?," CSIS, April 7, 2025, <https://www.csis.org/analysis/will-south-koreas-nuclear-ambitions-subside-next-five-years>; and Mark E. Manyin et al., "South Korea: Background and U.S. Relations," Congressional Research Service, IF10165, June 3, 2025, <https://www.congress.gov/crs-product/IF10165>.

15 Rebecca Davis Gibbons and Stephen Herzog, "Durable Institution Under Fire? The NPT Confronts Emerging Multipolarity," *Contemporary Security Policy* 43, no. 1 (2022): 50–79, <https://doi.org/10.1080/13523260.2021.1998294>; and Heather Williams, "The New Nuclear Sufficiency and Risk Reduction," *Washington Quarterly* 48, no. 1 (2025): 23–40, <https://doi.org/10.1080/0163660X.2025.2483614>.

16 National Nuclear Security Administration, "Russia's Disregard for Nuclear Safety and Security in Ukraine," U.S. Department of Energy, accessed November 2, 2025, <https://www.energy.gov/nnsa/russias-disregard-nuclear-safety-and-security-ukraine>; Mark Holt and Mary Beth D. Nikitin, "Iran's Nuclear Program: Status," Congressional Research Service, IN11883, updated October 4, 2024, <https://www.congress.gov/crs-product/IN11883>; U.S. Department of Defense, "Historically Successful Strike on Iranian Nuclear Site Was 15 Years in the Making," press release, September 16, 2025, <https://www.war.gov/News/News-Stories/Article/Article/4227082/historically-successful-strike-on-iranian-nuclear-site-was-15-years-in-the-maki/>; and Graham Scarbro, "Iran-Israel Conflict: A Quicklook Analysis of Operation Rising Lion" U.S. Naval Institute, June 2025, <https://www.usni.org/magazines/proceedings/2025/june/iran-israel-conflict-quicklook-analysis-operation-rising-lion>.

17 *Before the Subcommittee on Strategic Forces, Senate Armed Services Committee*, 119th Cong. (March 26, 2025) (statement of General Anthony J. Cotton, Commander, United States Strategic Command), https://www.armed-services.senate.gov/imo/media/doc/testimony_of_general_anthony_jcotton2.pdf#page=18; Office of the Director of National Intelligence, *Support Provided by the People's Republic of China to Russia* (Washington, DC: Office of the Director of National Intelligence, July 2023), https://democrats-intelligence.house.gov/uploadedfiles/odni_report_on_chinese_support_to_russia.pdf; and Ricardo Barrios and Andrew S. Bowen, "China-Russia Relations," Congressional Research Service, IF12100, September 13, 2023, <https://www.congress.gov/crs-product/IF12100>.

U.S. STRATEGIC POSTURE AND THE QUESTION OF SUFFICIENCY

In response to the evolving threat environment, Congress directed a review of the U.S. strategic posture in the FY 2022 National Defense Authorization Act.¹⁸ The Congressional Commission on the Strategic Posture of the United States (known as the Strategic Posture Commission [SPC]) reached bipartisan consensus on 81 recommendations, many requiring near-term action to have effect within the next decade.¹⁹ The commission concluded that the current nuclear modernization POR, while necessary, is insufficient for the emerging reality of two nuclear peers, as the POR was designed for 2010-era assumptions. One of the report's urgent recommendations was the modification of the U.S. theater nuclear force posture; however, it left unspecified what specific capability gaps exist.²⁰ In effect, the SPC handed the Department of Defense (DOD) a homework assignment: Determine what a "sufficient" nuclear arsenal looks like.

The SPC's concerns have been echoed across the federal government. In 2023, Senators Deb Fischer (R-NE) and Angus King (I-ME) raised concerns about the adequacy of U.S. regional deterrence during a Senate Armed Services hearing.²¹ In a subsequent *Washington Post* op-ed, the two senators warned that "the nuclear-force structure of the past will not suffice in the 2030s," cautioning that adversaries might doubt U.S. resolve if massive retaliation is the only tool available to respond to tactical nuclear use.²² The following year, then-Acting Assistant Secretary of Defense for Space Policy Vipin Narang stated that the DOD was "reviewing and prioritizing other ways we might adjust U.S. posture," to provide greater flexibility.²³

Senior military leaders have reinforced this theme. In a 2025 testimony, General Anthony Cotton, USSTRATCOM commander, stressed the need for flexible response options, repeating the point nine times in his prepared remarks.²⁴ General Thomas Bussiere, commander of Air Force Global Strike Command, similarly emphasized that the nuclear threat posed by Russia, China, North Korea, and Iran "underscores the importance of fielding a flexible and modern nuclear force to effectively deter them."²⁵

18 Sec. 1687, *National Defense Authorization Act for Fiscal Year 2022*, Public Law 117-81, 135 Stat. 1542 (Dec. 27 2021), <https://www.congress.gov/117/plaws/publ81/PLAW-117publ81.pdf#page=>

19 Madelyn R. Creedon et al., *America's Strategic Posture: Final Report of the Congressional Commission on the Strategic Posture of the United States* (Alexandria, VA: Institute for Defense Analysis, 2023), <https://www.ida.org/-/media/feature/publications/a/am/americas-strategic-posture/strategic-posture-commission-report.ashx>.

20 *Testimony before the Subcommittee on Strategic Forces, Senate Armed Services Committee*, 119th Cong. (May 20, 2025) (statement of General Thomas A. Bussiere, Commander, Air Force Global Strike Command), https://www.armed-services.senate.gov/imo/media/doc/bussiere_opening_statement.pdf; U.S. Department of Defense, *2022 National Defense Strategy of the United States of America, Including the 2022 Nuclear Posture Review and 2022 Missile Defense Review* (Washington, DC: U.S. Department of Defense, 2022), <https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.pdf>; and *Testimony before the Subcommittee on Strategic Forces, Senate Armed Services Committee*, 119th Cong. (May 20, 2025) (opening statement of Vice Admiral Johnny R. Wolfe, USN, director, Strategic Systems Programs), <https://armedservices.house.gov/sites/evo-subsites/republicans-armedservices.house.gov/files/hs-10-mar-2023-hasc-sf-hearing%20on%20u.s.%20and%20adversary%20hypersonic%20programs-%20final.pdf>.

21 *Hearing to Receive Testimony on Regional Nuclear Deterrence, before U.S. Senate Committee on Armed Services, Subcommittee on Strategic Forces* 118th Cong., 1st sess. (March 28, 2023), video, <https://www.armed-services.senate.gov/hearings/to-receive-testimony-on-regional-nuclear-deterrence>.

22 Deb Fischer and Angus King, "The Nuclear-Force Structure of the Past Will Not Suffice Now," *Washington Post*, September 5, 2023, <https://www.washingtonpost.com/opinions/2023/09/17/nuclear-force-structure-inadequate-king-fischer/>.

23 Vipin Narang, "Nuclear Threats and the Role of Allies: Remarks by Acting Assistant Secretary of Defense for Space Policy at CSIS," U.S. Department of Defense, speech transcript, August 1, 2024, <https://www.war.gov/News/Speeches/Speech/Article/3858311/nuclear-threats-and-the-role-of-allies-remarks-by-acting-assistant-secretary-of/>.

24 *Before the Subcommittee on Strategic Forces, Senate Armed Services Committee*, 119th Cong. (March 26, 2025) (statement of General Anthony J. Cotton, Commander, United States Strategic Command), https://www.armed-services.senate.gov/imo/media/doc/testimony_of_general_anthony_jcotton2.pdf#page=18.

25 David Vergun, "Nuclear Triad in Need of Modernization," *U.S. Department of Defense*, May 21, 2025, <https://www.war.gov/News/News-Stories/Article/Article/4194382/nuclear-triad-in-need-of-modernization/>.

Senior political and military leaders have stressed the need for flexible nuclear options, and analysts converge on a common set of attributes that such theater forces should have.²⁶ Common features of recommendations include survivability without lengthy generation, forward deployment or persistent presence, a range of yields, the ability to penetrate advanced defenses with high confidence, prompt delivery timelines, and the capacity to hold diverse target sets at risk. Some studies also highlight political considerations such as visibility to signal resolve and allied burden sharing.²⁷ Together, these attributes provide a useful framework for evaluating proposed changes to theater nuclear capabilities.

Proposals vary on how to achieve these capabilities. Some emphasize scaling planned capabilities, such as increasing the availability of B61 gravity bombs, B-21 bombers, and *Columbia*-class ballistic missile submarines (SSBNs), or accelerating the deployment of SLCM-Ns.²⁸ Others advocate rebalancing across domains by deploying low-yield systems on air, ground, and sea platforms in both Europe and the Indo-Pacific.²⁹ Still other analysts propose entirely new capabilities, including nuclear antiship missiles, nuclear-capable hypersonic missiles, and a variety of ground-launched nuclear systems.³⁰ Despite their differences, the proposals share a common premise: The United States requires more credible, theater-relevant nuclear options.

These debates extend beyond capabilities to questions of targeting philosophy and risk. Critics warn that expanding U.S. theater nuclear forces could drive arms races, strain alliance politics, or divert resources from conventional and defensive capabilities that may deliver greater effect.³¹ Some analysts argue that if deterrence rests on assured retaliation against cities and leadership, or countervalue targeting, additional nuclear options are unnecessary.³² Counterforce proponents, by contrast, contend that relinquishing the ability to hold adversary nuclear forces at risk would weaken extended deterrence in regional crises, and that abandoning the long-standing U.S. counterforce strategy would be high risk.³³ Some analysts even refute the arms race concerns entirely, arguing that

26 Creedon et al., *America's Strategic Posture*; Roberts et al., *China's Emergence as a Second Nuclear Peer*; and Weaver, *The Imperative of Augmenting U.S. Theater Nuclear Forces*.

27 Roberts et al., *China's Emergence as a Second Nuclear Peer*.

28 Creedon et al., *America's Strategic Posture*; Deb Fischer, "Fischer Strengthens Nuclear Deterrence, Protects Defense Spectrum in FY 2026 NDAA," press release, July 11, 2025, <https://www.fischer.senate.gov/public/index.cfm/2025/7/fischer-strengthens-nuclear-deterrence-protects-defense-spectrum-in-fy-2026-ndaa>; Mark Gunzinger, "The Case for the B-21 Raider," *Air & Space Forces Magazine*, March 31, 2023, <https://www.airandspaceforces.com/article/the-case-for-the-b-21-raider/>; and Robert Peters and Brent D. Sadler, "Columbia Submarine Fleet Production Should Be Radically Expanded," Heritage Foundation Backgrounder No. 3834, June 2024, <https://www.heritage.org/sites/default/files/2024-06/BG3834.pdf>.

29 Jonathan Trexel, "Countering the Asymmetry of Nuclear Strategy," *Global Security Review*, February 13, 2024, <https://globalsecurityreview.com/countering-the-asymmetry-of-nuclear-strategy/>.

30 Chris Andrews and Justin Anderson, *China's Theater-Range, Dual-Capable Delivery Systems: Integrated Deterrence and Risk Reduction Approaches to Counter a Growing Threat* (Washington, DC: National Defense University, August 2024), https://inss.ndu.edu/Portals/82/HDTRA1344728_NDU%20INSS%20CSWMD_TECREP_unclass_Final.pdf; Peters, *A Nuclear Posture Review*; Roberts et al., *China's Emergence as a Second Nuclear Peer*; and Weaver, *The Imperative of Augmenting U.S. Theater Nuclear Forces*.

31 Robert L. Gallucci, Vipin Narang, and Pranay Vaddi, "In Denial? Debating U.S. Nuclear Strategy," *Foreign Affairs*, August 19, 2025, <https://www.foreignaffairs.com/responses/denial-gallucci-narang-vaddi>; and Hans Kristensen, Matt Korda, Eliana Johns, and Mackenzie Knight-Boyle, "Strategic Posture Commission Report Calls for Broad Nuclear Buildup," Federation of American Scientists, October 12, 2023, <https://fas.org/publication/strategic-posture-commission-report-calls-for-broad-nuclear-buildup/>.

32 Charles L. Glaser, James M. Acton, and Steve Fetter, "The U.S. Nuclear Arsenal Can Deter Both China and Russia," *Foreign Affairs* 102, no. 5 (September/October 2023), <https://www.foreignaffairs.com/united-states/us-nuclear-arsenal-can-deter-both-china-and-russia>; Keir A. Lieber and Daryl G. Press, *U.S. Strategy and Force Posture for an Era of Nuclear Tripolarity* (Washington, DC: Atlantic Council, April 2023), <https://www.atlanticcouncil.org/wp-content/uploads/2023/04/US-Strategy-and-Force-Posture-for-an-Era-of-Nuclear-Tripolarity.pdf>.

33 Brad Roberts, ed. *Counterforce in Contemporary U.S. Nuclear Strategy* (Livermore, CA: Lawrence Livermore National Laboratory, May 2025), <https://cgsl.lnl.gov/sites/cgsl/files/2025-05/2025-0529-CGSR-Occasional-Paper-Counter->

both counterforce and countervalue strategies carry risks of competition, and that modest posture changes could simultaneously bolster deterrence and create space for renewed arms control.³⁴

There is thus broad agreement that U.S. strategy must adapt in the new nuclear age, but little consensus on how to do so and to what level. Concerns about arms races, alliance management, and trade-offs with conventional forces remain important to consider. The TTX examined here did not resolve those questions but does help fill practical and conceptual gaps by testing how regional U.S. nuclear capabilities affect the ability to meet U.S. objectives after an adversary's nuclear first use.

TTX DESIGN DECISIONS AND ASSUMPTIONS

The TTX deliberately began at the point of adversary nuclear first use and engaged a broad mix of participants to work through the challenge of follow-on planning. Most variables were held constant while one factor, the presence or absence of enhanced U.S. regional nuclear capabilities, was varied. This approach made it possible to compare teams directly and observe how differences in available capabilities shaped response option development.

The TTX's objective comprised the role of enhanced U.S. regional nuclear capabilities in achieving U.S. objectives after an initial failure of strategic deterrence. To that end, the TTX was designed to focus participants on nuclear force trade-offs rather than conventional or broader diplomatic, informational, military, and economic (DIME) options. At the same time, presidential guidance reminded players that other response options remained under consideration.

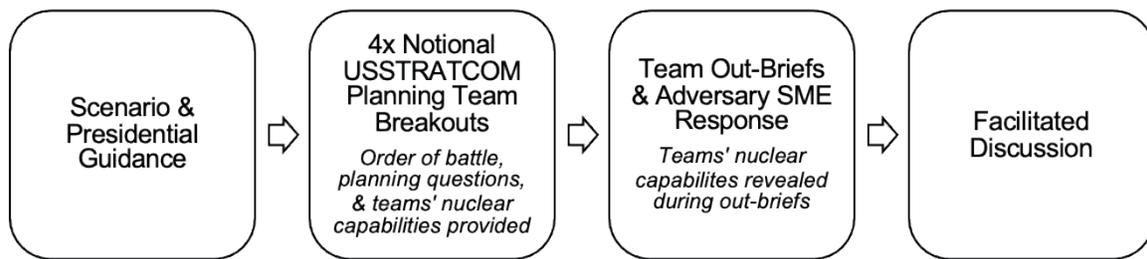
TEAMS AND STRUCTURE

The exercise was run as a single-turn game with four teams representing USSTRATCOM planning cells and one adversary subject matter expert (SME). Teams paired six early- to mid-career professionals—drawn from military, policy, international, interagency, and technical backgrounds—with a senior leader, such as a former defense or diplomatic official, to guide deliberations. The SME, played by a former senior defense official, later responded to the decisions each team made.

Collectively, participants received a scenario and presidential guidance brief before breaking into their respective teams for course of action (COA) development. During the breakouts, teams were provided capability sets, an order of battle, and planning questions, but they were unaware that their counterparts were operating with different capabilities. After the planning sessions, teams reconvened to present their COAs, receive an adversarial response from the SME, and participate in a facilitated discussion. A beta test was conducted in advance to refine scenario fidelity, player guidance, and timing. This game structure is presented in Figure 1.

34 force-In-Contemporary-US-Nuclear-Strategy.pdf; and Narang and Vaddi, "How to Survive the New Nuclear Age." Roberts, ed. *Counterforce in Contemporary U.S. Nuclear Strategy*; and Williams, "The New Nuclear Sufficiency and Risk Reduction."

Figure 1: Game Structure



SCENARIO

The selected scenario focused on a Chinese invasion of Taiwan culminating in People's Republic of China (PRC) nuclear first use.³⁵ The 2022 National Defense Strategy identified the PRC as the “pacing challenge,” and a Taiwan invasion is widely regarded as one of the most consequential and intensively studied contingencies.³⁶ To align with the expected availability of emerging U.S. systems such as the B-21 and LRSO, the timeline was set in 2030.³⁷

The escalation dynamics drew on prior analyses and wargames examining the potential role of nuclear weapons in a Taiwan conflict.³⁸ Although China's nuclear threshold is assessed as high, these studies emphasize that nuclear signaling and escalation risks cannot be dismissed. Anchoring the TTX on Chinese nuclear first use was not intended as a prediction, but rather as an initial condition to meet the TTX objectives.

In this scenario, gray zone operations escalated into a full-scale invasion of Taiwan. Initial Chinese gains stalled into a protracted conflict marked by major conventional escalation, including People's Liberation Army (PLA) strikes on Guam and U.S. strikes on Hainan. A low-yield nuclear detonation was then detected east of Luzon in the Philippine Sea, sinking the USS *Ronald Reagan*, damaging one destroyer and two support ships, killing more than 5,000 sailors and airmen, and injuring hundreds more from flash blindness and burns.

At this point, participants received presidential guidance: U.S. Indo-Pacific Command (USINDOPACOM) was the supported command and developed conventional COAs, while the president tasked USSTRATCOM to propose nuclear COAs to deter further PRC nuclear use and to assure allies of the U.S. commitment to extended deterrence. The desired end state was for the PRC to recognize that

35 While a simultaneous two-peer conflict would have best reflected concerns raised by the SPC and other studies, it was judged too complex for a short-format exercise.

36 U.S. Department of Defense, *2022 National Defense Strategy of the United States of America*; and U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2024*.

37 “B-21 Raider,” U.S. Air Force, accessed May 2025, <https://www.af.mil/About-Us/Fact-Sheets/Display/Article/2682973/b-21-raider/>; and U.S. Department of Defense, *Long Range Stand-Off Weapon (LRSO): Selected Acquisition Report, FY 2024 President's Budget* (Washington, DC: Defense Acquisition Visibility Environment, December 2022), https://www.esd.whs.mil/Portals/54/Documents/FOID/Reading%20Room/Selected_Acquisition_Reports/FY_2022_SARS/LRSO_SAR_DEC_2022.pdf.

38 Andrews and Anderson, *China's Theater-Range, Dual-Capable Delivery Systems*; Mark Cancian, Matthew Cancian, and Eric Heginbotham, *Confronting Armageddon: Wargaming Nuclear Deterrence and Its Failures in a U.S.-China Conflict over Taiwan* (Washington, DC: CSIS, December 2024), <https://www.csis.org/analysis/confronting-armageddon>; Stacie Pettyjohn, Becca Wasser, and Chris Dougherty, *Dangerous Straits: Wargaming a Future Conflict over Taiwan* (Washington, DC: Center for New American Security, June 15, 2022), <https://www.cnas.org/publications/reports/dangerous-straits-wargaming-a-future-conflict-over-taiwan>; Greg Weaver, *The Role of Nuclear Weapons in a Taiwan Crisis* (Washington, DC: Atlantic Council, November 2023); and Heather Williams et al., *Project Atom 2024: Intra-War Deterrence in a Two-Peer Environment* (Washington, DC: CSIS, November 2024), <https://www.csis.org/analysis/project-atom-2024-intra-war-deterrence-two-peer-environment>.

nuclear coercion was unacceptable and that the United States would respond to protect itself, restore deterrence, and assure allies. The specific nuclear capabilities available to U.S. forces became the central variable shaping the options that teams could consider.

CAPABILITIES

The current nuclear modernization POR, including B-21s, LRSOs, and SLCM-Ns, served as the control case. The treatment case added two systems frequently proposed in the literature on U.S. theater nuclear posture and tailored to the Indo-Pacific scenario: a ground-launched nuclear missile and an air-delivered nuclear antiship cruise missile. These additional systems were deployed in theater, whereas the control case's in-theater presence was limited to sea-launched systems. This design tested how different nuclear force postures and attributes shaped decisionmaking (see Table 1 for each team's full capability sets).

The ground-launched system drew on proposals for nuclear-capable ground-launched ballistic missiles (GLBMs) and ground-launched cruise missiles (GLCMs), designed to enable penetration of enhanced defenses, allow sustained deployment in theater, and expand allied sharing options.³⁹ The terminal guidance of the ground-launched system was left unspecified to allow flexibility. By contrast, the air-delivered antiship capability was explicitly tailored to the scenario, given the scenario's air-delivered nuclear strike on U.S. maritime assets by the PRC, and could serve as a response in kind.⁴⁰

Table 1: Notional USSTRATCOM Capability Sets

Team	Land	Sea	Air
Teams 1 & 2 (POR)	400 Minuteman III missiles on alert; high yield	4 SSBNs in the Atlantic and 6 SSBNs in the Pacific (3 immediately available for launch execution, 3 transiting), each with 20 missiles loaded; low-to-medium yield 1 SSN in the East China Sea with 4 nuclear-armed SLCM-Ns; low yield	10 B-2s (ready at Whiteman AFB, MO), each with up to 16 B-61s; low-to-medium yield 10 B-52s (located at Minot AFB, ND), each with up to 20 ALCMs; medium yield 10 B-21s (stationed at Ellsworth AFB, SD), each with up to 8 LRSOs; low-to-medium yield
Teams 3 & 4 (POR+)	Same as Teams 1 & 2 1 ground-launched nuclear missile in-theater with 1 warhead; medium yield	Same as Teams 1 & 2	Same as Teams 1 & 2 1 squadron of F-35s in-theater with 10 nuclear-armed antiship cruise missiles; low-to-medium yield

Note: Teams 1 and 2 received the control case (POR), while Teams 3 and 4 received the treatment case (POR+), which added two in-theater systems. Teams were not informed of these differences until their out-briefs, enabling comparison of decisionmaking under alternative force postures and attributes.

Source: Author's analysis.

39 Andrews and Anderson, *China's Theater-Range, Dual-Capable Delivery Systems*; Peters, *A Nuclear Posture Review for the Next Administration*; Roberts et al., *China's Emergence as a Second Nuclear Peer*; and Weaver, *The Imperative of Augmenting U.S. Theater Nuclear Forces*.

40 Analysts have emphasized that holding Chinese maritime forces at risk will be central to any tailored deterrence strategy for China; see Peters, *A Nuclear Posture Review for the Next Administration*. Additionally, some analysts claim that if the United States compensates for conventional inferiority with nuclear weapons in a second theater, additional nuclear capabilities may be required, including the ability to strike mobile targets such as underway naval vessels; see Roberts et al., *China's Emergence as a Second Nuclear Peer*; and Weaver, *The Imperative of Augmenting U.S. Theater Nuclear Forces*. These two additional capabilities were not selected for feasibility or fielding likelihood, but because they recur in the literature as attributes likely to matter for regional contingencies.

DESIGN CONSTRAINTS AND ASSUMPTIONS

Operational variables were simplified to foster strategic-level deliberations. Chinese nuclear use was ambiguous as to whether Beijing directly targeted the carrier strike group or detonated nearby. Allies were portrayed as broadly supportive of the United States, offering statements, force deployments, and basing. Since the treatment case introduced in-theater systems without specifying their locations, teams could assume allied basing if necessary. All U.S. nuclear forces were assumed fully generated at the scenario drop-off. The order of battle, provided as a map, included U.S. and allied forces as well as PRC mainland, coastal, maritime, amphibious, artificial island, and Taiwan-based forces and assets. Teams were free to target beyond those listed or to propose demonstration strikes. Many operational details, such as kill probabilities, were unspecified. These simplifications inevitably reduced realism but kept discussions at the strategic level, focusing on the role of nuclear force posture and attributes in decisionmaking after deterrence failure.

TTX OUTCOMES

Across teams, players tended to converge on proportional-plus responses, pairing a strike against a People's Liberation Army Navy (PLAN) carrier strike group with one additional target. PRC-controlled artificial islands were the next most common targets, seen as militarily useful and less escalatory than mainland options. Demonstration strikes were dismissed as inadequate following the loss of a U.S. carrier and its personnel; players emphasized that because all U.S. forces were already generated at the time of China's strike, further signaling without effect would not credibly shift Beijing's calculus. Comparatively, mainland strikes appeared in only one COA and were otherwise considered too escalatory (see Table 2).

System selections reflected these targeting preferences. The only team that did not target the PLAN carrier strike group explained that they wanted to but that they doubted that the SLCM-N could defeat mobile targets. Despite the senior leaders' assessments that the SLCM-N was unlikely to succeed against carriers, two other teams included it in their COAs. By contrast, one of the teams with additional capabilities relied on F-35s with nuclear antiship missiles to target the PLAN carrier instead of using the SLCM-N.

One of the four teams proposed a B-21/LRSO strike on the mainland bomber base used to conduct China's first-use nuclear strike. Additionally, ground-launched missiles, though frequently discussed in the literature, were not employed by either of the POR+ teams. The adversary SME assessed that proportional-plus options, such as striking the carrier group plus one additional target, sent the clearest signal of U.S. resolve. The adversary SME also judged that delays in employing continental U.S.-based bombers like the B-21 carried undue risk.

Table 2: Nuclear COAs by Team

Team	System(s) Used	Targets Chosen
Team 1 (POR)	SLCM-N, B-21, or B-61 (most survivable option)	COA 1: PLAN carrier + other PLAN assets at sea COA 2: PLAN carriers + PRC-controlled artificial islands
Team 2 (POR)	SLCM-Ns	PRC-controlled artificial islands
Team 3 (POR+)	F-35s with nuclear antiship cruise missiles	PLAN carrier strike group + PRC-controlled artificial islands
Team 4 (POR+)	SLCM-N + B-21 with LRSOs	PLAN carrier strike group + mainland bomber base

Note: Teams converged on proportional-plus strikes, especially against the PLAN carrier strike group. Uncertainty about the effectiveness of the SLCM-N to defeat mobile targets influenced Team 2's chosen target.

Source: Author's analysis.

ESCALATION MANAGEMENT AND ADVERSARY PERCEPTIONS

Desire for escalation management strongly shaped COA development. Participants sought responses that would impose costs without inviting uncontrolled escalation, but they were divided over how Beijing might interpret different U.S. nuclear strikes. Participants expressed some confidence that their chosen options would achieve the intended military effects, but less confidence that those strikes would produce the desired cognitive effects on adversary leaders.

Uncertainty about adversary perceptions shaped discussions throughout the TTX. Players questioned whether China's initial nuclear strike was intended as escalation or if it was an attempt to reestablish deterrence. They also debated the cultural and political salience of the PRC-controlled artificial islands, including whether striking them would be considered proportionate or provocative. A further point of contention was whether the use of strategic versus non-strategic systems would matter in Beijing's eyes, with some arguing that any nuclear use would be perceived as strategic.

Teams held back certain systems, such as the bombers, SSBNs, and ground-launched missiles, to preserve options in case deterrence was not restored and the conflict escalated into subsequent nuclear exchanges. That choice sparked further debate over whether withholding capabilities was consistent with presidential guidance to restore deterrence quickly.

These dynamics echoed long-standing debates on the viability of keeping nuclear employment limited. Daugherty, Levi, and von Hippel argue there is no assurance of control once the nuclear threshold is crossed, and Brodie warns that reciprocal low-yield strikes could still spiral into strategic exchange.⁴¹ In the current TTX, those theoretical concerns manifested in practice as players wrestled with the tensions among escalation control, adversary perceptions, and mission accomplishment, underscoring the broader question of whether limited nuclear employment can be both credible and controllable.

ATTRIBUTES AND SYSTEM CHOICES

Players most strongly weighed their options based on penetrability, survivability, and effectiveness against their desired targets. Standoff systems such as the SLCM-N, B-21 with LRSO, and the nuclear antiship missile were repeatedly favored as being more likely to penetrate China's layered defenses and to remain available for follow-on strikes if deterrence was not restored. This emphasis reflected Weaver's point that limited theater responses demand high confidence.⁴² In a large exchange, it may be tolerable for some weapons to be intercepted, but in a small strike, failure to reach the target risks failing to achieve objectives.

Survivability was considered in terms of second-strike capability, and players prioritized options that would remain credible after first use. One of the POR+ teams judged the ground-launched system as too vulnerable in this regard and chose not to employ it. In practice, however, survivability can be achieved through mobility, hardening, or concealment.⁴³ At the same time, the loss of a U.S. carrier to PRC nuclear first use pushed players toward Chinese maritime targets, which elevated effectiveness against mobile maritime forces as a central consideration. This aligned with literature emphasizing

41 William Daugherty, Barbara Levi, and Frank von Hippel, "The Consequences of 'Limited' Nuclear Attacks on the United States," *International Security* 10, no. 4 (Spring 1986): 3–45, <https://muse.jhu.edu/article/446172/summary>; and Bernard Brodie, "Strategy Hits a Dead End," *Harper's Magazine*, October 1955, 33–39.

42 Weaver, *The Imperative of Augmenting U.S. Theater Nuclear Forces*.

43 Thomas Urbanek, "US Nuclear Deterrence: Global Threats and Emerging Entities," *Journal of the Americas* 5, no. 1 (2023): 241–57, [https://www.airuniversity.af.edu/Portals/10/JOTA/journals/Volume-5_Issue-1/23-Urbanek_eng%20\(3\).pdf](https://www.airuniversity.af.edu/Portals/10/JOTA/journals/Volume-5_Issue-1/23-Urbanek_eng%20(3).pdf); and Thomas MacDonald, "Tracking Mobile Missiles," *Journal of Strategic Studies* 48 no. 2 (2025): 297–333, <https://doi.org/10.1080/01402390.2024.2435961>.

maritime forces as critical targets in tailored deterrence strategies for China, particularly when conventional options are degraded. The team that employed the antiship cruise missiles valued the missiles' ability to hold moving targets at risk, though their accompanying ground-launched system may have been overlooked because its terminal guidance was unspecified.

Other attributes received comparatively less attention in this TTX. Players either rejected the high-yield options outright or concluded that yield mattered less than whether a strike achieved its intended effects. Weapon delivery timelines (promptness) were also discounted since all forces were assumed generated at the scenario drop-off. Even so, two teams discounted continental U.S.-based options, expressing concern that visible deployments could make those forces more vulnerable before reaching their targets. The adversary SME, by contrast, emphasized that promptness would shape adversary decisionmaking.

Together, these dynamics showed that the attributes identified in prior analyses provided a useful lens for evaluating regional nuclear forces, but their relative importance shifted with the scenario and crisis dynamics. In this Indo-Pacific scenario, survivability, penetrability, and effectiveness against mobile maritime forces dominated. In a different contingency, the weight on each attribute could look very different. This variability underscores the value of maintaining flexible response options.

ABSENCE OF CONVENTIONAL SUPPORT

Conventional support to nuclear operations, defined as conventional capabilities that prepare the battlespace for nuclear use or that complement nuclear strikes, emerged as a recurring need.⁴⁴ Participants repeatedly noted that conventional operations would enhance or augment the attributes they valued most in nuclear systems: survivability, penetrability, and effectiveness against likely targets.

This dynamic was evident in both the beta test and the main exercise. In the beta, all teams independently incorporated conventional operations into their COAs to help degrade Chinese defenses, even though such options were not provided. The same logic appeared in the main TTX discussions, where players emphasized the need to degrade Chinese anti-access/area denial (A2/AD) and intelligence, surveillance, and reconnaissance (ISR) systems to enhance penetrability and survivability. Several participants went further, arguing that they would have preferred to target the PLAN carrier conventionally rather than with nuclear weapons, citing doubts about the effectiveness of the SLCM-N against mobile maritime targets.

These discussions revealed that players viewed conventional operations as both a complement to nuclear options, enabling them to succeed, and, in some cases, a substitute for them. The nuclear-only design of the TTX highlighted this point. Even when asked to focus exclusively on nuclear COAs, participants consistently raised conventional support as essential. Although this exercise varied nuclear posture, the absence of conventional options constrained perceived flexibility arguably more than the absence of specific nuclear systems.

CONCLUSION

This TTX produced three key findings:

1. Uncertainty about adversary perceptions shaped response planning, with players often more confident in achieving military rather than cognitive effects.

⁴⁴ U.S. Air Force, *Nuclear Operations*, Air Force Doctrine Publication 3-72 (U.S. Air Force, 2025), last updated August 4, 2025, https://www.doctrine.af.mil/Portals/61/documents/AFDP_3-72/3-72-AFDP-NUCLEAR-OPS.pdf.

2. Of the theater nuclear force attributes identified in prior analyses, penetrability, survivability, and effectiveness against likely targets most strongly influenced system choices in this scenario.⁴⁵
3. Conventional support to nuclear operations emerged as critical, even in a nuclear-only exercise.

These findings demonstrated some of the practical challenges of determining what a “sufficient” nuclear POR might entail. In this TTX, force attributes mattered: Teams with the current POR questioned their ability to strike mobile maritime targets. Yet the enhanced nuclear force posture (POR+) neither eliminated concerns about penetrating advanced defenses and survivability nor guaranteed confidence in meeting the president’s objective of restoring deterrence. Capabilities that improve flexibility and hold diverse targets at risk may help, but the cognitive dimension of deterrence remains hard to satisfy in practice.

Several participants noted that while the SLCM-N provided a survivable, in-theater option, they wished it were better suited for engaging mobile maritime targets. Those without access to the nuclear antiship cruise missile viewed that system as potentially decisive in this scenario, while others desired a conventional mobile-target defeat capability instead. Across participants, there was broad agreement on the need for conventional forces to prepare the battlespace for nuclear strikes. In turn, assessing nuclear sufficiency requires attention to the role conventional forces can play in augmenting the U.S. nuclear force.

The TTX also demonstrated clear educational value. Many wargames and exercises end once nuclear use occurs, treating follow-on response planning as beyond scope.⁴⁶ This exercise instead began after nuclear use, requiring participants to grapple with subsequent planning and to stress test their assumptions. In doing so, it exposed participants without planning backgrounds to the complexities of nuclear decisionmaking under crisis conditions and directly addressed calls to raise the “nuclear IQ” across a broader community.⁴⁷

Future TTXs should build on this approach by incorporating multiple turns, additional teams, and defined kill probabilities to support more robust evaluation of deterrence and escalation dynamics. Expanding the design to include conventional and nonkinetic response options, varied force postures, and a broader range of contingencies, including simultaneous peer crises, would provide a stronger foundation for assessing the sufficiency challenge identified by the SPC.

Determining what constitutes a sufficient nuclear posture for a two-nuclear-peer threat environment requires balancing nuclear and conventional forces, offensive and defensive systems, and ensuring that future investments deliver timely, tangible gains. TTXs like this one can play a valuable role in sharpening thinking on nuclear dilemmas and generating insights to inform future analysis.

45 Creedon et al., *America’s Strategic Posture*; Roberts et al., *China’s Emergence as a Second Nuclear Peer*; and Weaver, *The Imperative of Augmenting U.S. Theater Nuclear Forces*.

46 Robert Peters, Justin Anderson, and Harrison Menke, “Deterrence in the 21st Century: Integrating Nuclear and Conventional Force,” *Strategic Studies Quarterly* (Winter 2018), <https://wmdcenter.ndu.edu/Portals/97/MenkeAndersonPeters.pdf?ver=2018-12-03-130949-563>.

47 Buchanan, “Project Atom 2024”; and Hruby, “NNSA’s Journey.”

U.S. Partners and Allies



The United Kingdom's Contribution to the Reassurance of Baltic Allies

*“Moscow Has Character;
London Has Considerations”*

By Mar Casas Cachinero¹

INTRODUCTION

In what was described as a “rare” showcase of the United Kingdom’s nuclear deterrent, in early 2025 Prime Minister Keir Starmer welcomed back one of the Royal Navy’s four ballistic missile submarines (SSBNs) that guarantee the country’s continuous at-sea deterrence (CASD).² Thanking the crew for their service, the prime minister declared, “There is no greater duty than the one [the submariners] carry—no task more vital. Our security, *NATO’s security*, and the preservation of peace depend on them.”³ In June, following the publication of the Labour government’s “NATO-first” Strategic Defence Review, London announced it would join NATO’s dual-capable aircraft (DCA) nuclear-sharing mission with the aim of enhancing the alliance’s nuclear deterrence.⁴

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- 2 Deborah Haynes, “PM Makes Rare Visit to Nuclear-Armed Submarine to Show UK’s Strength – but Putin Will Notice a Potential Weakness,” Sky News, March 20, 2025, <https://news.sky.com/story/sir-keir-starmer-visits-nuclear-armed-submarine-as-tensions-grow-with-russia-13332279>.
- 3 Keir Starmer, “PM Speech at the Dreadnought Keel Laying Ceremony: 20 March 2025,” GOV.UK, March 20, 2025, <https://www.gov.uk/government/speeches/pm-speech-at-the-dreadnought-keel-laying-ceremony-20-march-2025> [emphasis added].
- 4 Royal Air Force, “RAF F-35A Marks a Significant Step in Delivering a More Lethal Integrated Force and Joining NATO Nuclear Mission,” press release, June 25, 2025, <https://www.raf.mod.uk/news/articles/raf-f-35a-marks-a-significant-step-in-delivering-a-more-lethal-integrated-force-and-joining-nato-nuclear-mission/>.

Although the United Kingdom has for decades committed its nuclear deterrent to the security and defense of the alliance, not all European NATO allies see this commitment as credible. Notwithstanding the recent uptick produced by the second Trump administration's threats of abandoning NATO, there has been little public debate in recent years over how, in concrete terms, the UK contribution to European security is configured. This signals the relatively low degree of consideration the country's partners have for the extended deterrence effect of its nuclear weapons. Nations along NATO's eastern flank, including Estonia, Latvia, and Lithuania, feel a stronger need for reassurance due to their proximity and heightened sensitivity to Russia, particularly since the start of the war in Ukraine. Amid growing concerns over the credibility of U.S. extended deterrence, the United Kingdom—the only other state whose nuclear forces are committed to the defense of NATO—is uniquely positioned to reinforce the U.S. nuclear guarantee by credibly demonstrating how its nuclear capabilities enhance the alliance's nuclear posture.⁵ In turn, heightened allied reassurance reinforces the nuclear nonproliferation regime and can strengthen overall deterrence against Russia.⁶

This paper assesses how credible the official commitment of the United Kingdom's nuclear deterrent to the collective defense of NATO is to Estonia, Latvia, and Lithuania. Looking at one of the regions in Europe where the need for reassurance is most acute—given these countries' geographical proximity and historical ties to Russia—potentially offers the most relevant and useful insights on allied expectations of London. Furthermore, this is a region where the United Kingdom involves itself in security and defense matters but where a deepening and widening of its presence and leadership is nonetheless possible—and would be very much welcomed.⁷

After offering a brief overview of UK nuclear policy and its role within NATO, as well as an applied description of allied reassurance, this paper delves into Baltic countries' views on the United Kingdom's commitment to their defense within the framework of NATO's overall reassurance against the Russian threat. This central part of the analysis is based on research interviews with security and defense experts from Estonia, Latvia, and Lithuania.⁸ These insights are analyzed in the context of the United Kingdom's 2025 Strategic Defence Review and expert commentary on UK nuclear policy and the DCA acquisition. Findings and implications are summarized in the conclusion.

THE UNITED KINGDOM AND NATO NUCLEAR POLICY

“As long as nuclear weapons exist, NATO will remain a nuclear alliance,” the organization's 2010 Strategic Concept declared.⁹ Subsequent posture reviews and strategic concepts have since reaffirmed this statement. The strategic nuclear forces of France and the United Kingdom are said to possess “a deterrent role of their own,” as well as enhance overall alliance security in support of the United States'

5 “Written Evidence Submitted by the Ministry of Defence,” UK Parliament, January 31, 2025, <https://committees.parliament.uk/writtenevidence/136461/html/>.

6 Jennifer Bradley, “Preventing the Nuclear Jungle: Extended Deterrence, Assurance, and Nonproliferation,” *Joint Force Quarterly* 112 (1st Quarter 2024): 70–75, <https://digitalcommons.ndu.edu/joint-force-quarterly/vol112/iss1/10>.

7 See, for instance, Tomas Jermalavičius and Alice Billon-Galland, *British Power in Baltic Weather: The UK's Role in Nordic-Baltic Security and UK-Estonia Defence Cooperation* (Tallinn: International Center for Defence and Security, 2023), https://icds.ee/wp-content/uploads/dlm_uploads/2023/07/ICDS_Report_British_Power_in_Baltic_Weather_Jermalavicius_Billon-Galland_July_2023.pdf.

8 These semi-structured interviews were conducted online during the first half of July 2025. They were all guided by the same questions and lasted for approximately 30 minutes each. The author interviewed four experts working at policy think tanks: one from Latvia, one from Lithuania, and two from Estonia.

9 NATO, *Strategic Concept for the Defence and Security of the Members of the North Atlantic Treaty Organization* (Brussels: NATO Public Diplomacy Division, 2010), 14, https://www.nato.int/nato_static_fl2014/assets/pdf/pdf_publications/20120214_strategic-concept-2010-eng.pdf.

extended deterrence policy; jointly, NATO's nuclear forces are the "supreme guarantee" of collective defense.¹⁰ While the "ultimate authority within NATO" is the North Atlantic Council, the Nuclear Planning Group (NPG) is the central forum and most senior body for the development and implementation of the alliance's nuclear policy. NPG discussions cover a wide range of nuclear matters, including the overall effectiveness of the nuclear deterrent.¹¹ All allies, regardless of whether or not they possess or host nuclear weapons, participate in the NPG, with the sole exception of France.

Important elements of NATO's deterrence posture involve the United States' forward-deployed nuclear weapons in Europe and the DCA capability several European NATO allies—soon to include the United Kingdom—contribute to the alliance.¹² Allied F-35A fighter aircraft "are available for nuclear roles at various level of readiness," and participating nations' personnel are trained accordingly. These aircraft take part in Exercise Steadfast Noon, NATO's annual nuclear exercise meant to ensure the "credibility, effectiveness, safety and security" of the nuclear mission.¹³ Following the publication of the 2025 Strategic Defence Review—in which the United Kingdom pledged to join NATO's nuclear burden-sharing arrangements—London announced it would procure 12 F-35A aircraft.¹⁴ This will entail hosting U.S. forward-deployed nuclear forces, as the DCAs will be certified to carry the upgraded U.S. B61-12 tactical nuclear-armed gravity bombs.¹⁵ This acquisition "complements the UK's own operationally independent nuclear deterrent," according to the Royal Air Force, which will now regain a nuclear role for the first time since the 1998 withdrawal of the WE-177 bomb, the United Kingdom's last sovereign air-launched nuclear capability.¹⁶

In the words of UK Secretary of State for Defence John Healey, NATO remains the "cornerstone" of UK security, as it has been for decades.¹⁷ The country first committed its nuclear deterrent to the defense of NATO following the 1962 Nassau Agreement, which was the basis for the Polaris Sales Agreement and subsequent U.S.-UK nuclear cooperation frameworks. Except where London "may decide that supreme national interests are at stake," British submarines equipped with the Polaris missiles were committed to the multilateral NATO nuclear force.¹⁸ The current shape and policy of the United Kingdom's nuclear deterrent continues to be defined by these two agreements.¹⁹ Some have argued that it is challenging to discern a specific role within NATO for UK strategic forces "that would not be more adequately met by U.S. nuclear forces."²⁰ During the Cold War, the dominant

10 "NATO 2022 Strategic Concept," NATO, June 29, 2022, https://www.nato.int/nato_static_fl2014/assets/pdf/2022/6/pdf/290622-strategic-concept.pdf.

11 "Nuclear Planning Group (NPG)," NATO, updated May 9, 2022, https://www.nato.int/cps/en/natohq/topics_50069.htm.

12 Royal Air Force, "RAF F-35A."

13 "NATO's Nuclear Deterrence Policy and Forces," NATO, updated June 24, 2025, https://www.nato.int/cps/em/natohq/topics_50068.htm.

14 UK Ministry of Defence, *The Strategic Defence Review 2025 – Making Britain Safer: Secure at Home, Strong Abroad* (London: UK Ministry of Defense, 2025), 38, https://assets.publishing.service.gov.uk/media/683d89f181deb72cce2680a5/The_Strategic_Defence_Review_2025_-_Making_Britain_Safer_-_secure_at_home__strong_abroad.pdf; and Royal Air Force, "RAF F-35A."

15 Claire Mills, *Strategic Defence Review 2025: The UK's Nuclear Deterrent* (London: House of Commons Library, 2025), 5, 9, <https://commonslibrary.parliament.uk/research-briefings/cbp-10275/>.

16 Royal Air Force, "RAF F-35A"; and Mills, *Strategic Defence Review*, 11–12.

17 Louisa Brooke-Holland, "The Forthcoming Strategic Defence Review 2025: FAQ," House of Commons Library, May 30, 2025, <https://commonslibrary.parliament.uk/research-briefings/cbp-10153/>.

18 "Polaris Sales Agreement," U.S. Navy, accessed April 9, 2025, <https://www.ssp.navy.mil/About-Us/SSP-Mission/Safeguard/Polaris-Sales-Agreement/>.

19 Paul Burton, "Bahamian Rhapsody: Nassau 1962 and Trident," Royal United Services Institute, September 10, 2018, <https://www.rusi.org/publication/bahamian-rhapsody-nassau-1962-and-trident>.

20 Ian Davis, *The British Bomb and NATO: Six Decades of Contributing to NATO's Strategic Nuclear Deterrent* (Stockholm: Stockholm International Peace Research Institute, 2015), v, <https://www.sipri.org/publications/2015/british-bomb-and-nato-six-decades-contributing-natos-strategic-nuclear-deterrent>.

rationale of the so-called British nuclear weapons establishment was the argument that a separate center of decisionmaking within the alliance and in Europe “added uncertainty” to the Soviet Union’s calculations, making deterrence more effective.²¹ However, the “exact nature” of the UK nuclear weapons’ contribution to NATO has become “increasingly obscure” in recent decades.²² The argument for having “separate centres of decision-making” still forms the basis of NATO’s stated rationale: Adversaries’ calculations when considering an attack are complicated by having to account for not only NATO’s decisionmaking, but also that of individual leaders in Washington, London, and Paris.²³

The United Kingdom has long had a policy of strategic ambiguity in which the quantity and types of targets to be held at risk by the Trident nuclear submarine program are deliberately left unclear. During the Cold War, the choice of targets was guided by the “Moscow criterion”—the ability to destroy Moscow to deter a Soviet attack on the United Kingdom.²⁴ The 2021 Integrated Defence Review officialized the strategic ambiguity doctrine by declaring the country would no longer be transparent about the specifics of its nuclear stockpile nor offer indications on “precisely when, how, and at what scale” nuclear weapons would be used.²⁵ At the same time, it announced an increase to its nuclear stockpile ceiling to 260 warheads, reversing decades of gradual reduction.²⁶ According to the 2025 Strategic Defence Review, ambiguity enhances the deterrent effect “by complicating the calculations of potential aggressors.”²⁷ Experts have pointed out that beyond undermining the United Kingdom’s stance as a responsible nuclear power, such ambiguity prevents allies and enemies alike from knowing “what a potential nuclear response would look like in a crisis.”²⁸ This uncertainty, although arguably a contributing factor to deterrence, does pose acute challenges to the parallel goal of reassuring allies, who require greater certainty and credibility.²⁹

The changing security landscape, marked by Russia’s full-scale invasion of Ukraine in 2022 and the United States’ increased focus on the Indo-Pacific, has once again raised questions in European capitals over the U.S. nuclear reassurance to allies—though the credibility of U.S. extended deterrence has been in doubt for decades.³⁰ Given the second Trump administration’s threatening rhetoric against the transatlantic alliance, the lack of clarity regarding the political commitment by the primary guarantor of allied security has reawakened fears of abandonment among European NATO allies and prompted calls for discussions on whether “nuclear security from the UK and France” could apply to other nations such as Germany.³¹ Despite growing arguments for the United Kingdom to “American-proof its long-term nuclear future” (as discussed below), there are few options for rapidly enhancing the United Kingdom’s nuclear capabilities and none that would be “easy, cheap, or

21 Ibid., 7.

22 Ibid., 33.

23 “NATO’s Nuclear Deterrence,” NATO.

24 Geoffrey Chapman, “Britain’s Deterrent and the ‘Moscow Criterion,’” Royal United Services Institute, August 1, 2018, <https://www.rusi.org/networks/uk-poni/nuclear-reactions/britains-deterrent-and-moscow-criterion>.

25 “The UK’s Nuclear Deterrent: The National Endeavour Explained,” UK Ministry of Defence, updated October 6, 2025, <https://www.gov.uk/government/publications/uk-nuclear-deterrence-factsheet/the-uks-nuclear-deterrent-the-national-endeavour-explained>.

26 Heather Williams, “U.K. Nuclear Weapons: Beyond the Numbers,” War on the Rocks, April 6, 2021, <https://warontherocks.com/2021/04/u-k-nuclear-weapons-beyond-the-numbers/>.

27 UK Ministry of Defence, *Strategic Defence Review 2025*, 98.

28 Williams, “U.K. Nuclear Weapons”; and Davis, *The British Bomb*, 34–35.

29 Bradley, “Preventing the Nuclear Jungle.”

30 Michaela Dodge, “Trends in Allied Assurance: Challenges and Questions,” National Institute for Public Policy, October 21, 2024, <https://nipp.org/wp-content/uploads/2024/10/IS-602.pdf>.

31 Astrid Chevreuil and Doreen Horschig, “Can France and the United Kingdom Replace the U.S. Nuclear Umbrella?,” CSIS, *Critical Questions*, March 4, 2025, <https://www.csis.org/analysis/can-france-and-united-kingdom-replace-us-nuclear-umbrella>.

necessarily politically expedient.”³² Since those at the forefront of the Russian threat, including in the Baltic region, are unwilling to leave their security to chance, pragmatic nuclear dialogue and creative efforts are needed to demonstrate deterrence credibility and reassure NATO allies.³³

BALTIC PERCEPTIONS OF THE UK NUCLEAR DETERRENT'S CONTRIBUTION

Estonia, Latvia, and Lithuania see the United Kingdom as an important, trustworthy contributor to their deterrence and defense within the framework of the NATO alliance—with a few important caveats. “It’s good to have the UK, [but] it’d be good to have more of the UK in the region,” was an overarching observation during the author’s research interviews with security and defense experts from the Baltic countries.³⁴ This section explores these experts’ views and places them in the context of UK official policy, leading to four key findings. First, although Baltic, UK, and NATO threat perceptions are generally aligned, important gaps remain in their respective perception of required capabilities and the sense of urgency. Second, British on-the-ground conventional forces provide valuable reassurance and deterrence for Baltic states. Third, these countries are concerned over the credibility of the UK nuclear deterrent; this is driven by its perceived political unwillingness to use nuclear weapons and the related lack of flexible options in the UK arsenal, as well as a broader lack of reassurance credibility due to the country’s shortcomings in the conventional realm. Fourth, although the Baltic states welcome London’s decision to join NATO’s nuclear-sharing arrangements as a positive step in demonstrating to Russia that its actions have consequences, their focus for any further investments remains the conventional realm.

NATO, UK, AND BALTIC THREAT PERCEPTION

The United Kingdom’s most recent Strategic Defence Review (SDR) points to two key elements in today’s security landscape that supposedly pose significant challenges to allied reassurance in the Euro-Atlantic and complicate deterrence and escalation dynamics. The first, Russia’s “increasing reliance on nuclear coercion,” is evident in its war against Ukraine, the modernization and expansion of its nuclear capabilities, and threats of limited nuclear use in warfighting. Meanwhile, the expansion of China’s nuclear capabilities, as well as the potential for collaboration and opportunism among various “nuclear challengers,” is seen to “place demands” on the United States’ nuclear forces and, consequently, its capability to extend deterrence to NATO allies.³⁵ In response to these two trends, the SDR recommends the UK government explore measures to support the United States and NATO in “strengthening extended deterrence” and “enhancing its contribution to deterrence and assurance in the Euro-Atlantic.”³⁶

Estonia, Latvia, and Lithuania share a positive assessment of the evolution of NATO’s threat perception, which is “on the right track” and “has gotten closer and closer to our [Baltic] understanding and perception of the threat,” particularly since the alliance’s 2022 Strategic Concept.³⁷ The region particularly welcomes NATO’s adapted defense and deterrence posture, its tailoring of exercises to “the actual threat,” and its focus on regions “that need more attention,” as well as the

32 Rym Momtaz et al., “Taking the Pulse: Can Europeans Build Their Independent Extended Nuclear Deterrent?” Carnegie Endowment for International Peace, *Strategic Europe*, April 3, 2025, <https://carnegieendowment.org/europe/strategic-europe/2025/04/taking-the-pulse-can-europeans-build-their-independent-extended-nuclear-deterrent?lang=en>.

33 Bradley, “Preventing the Nuclear Jungle.”

34 Expert interview 1, conducted July 3, 2025.

35 UK Ministry of Defence, *Strategic Defence Review 2025*, 99.

36 Ibid.

37 Expert interview 4, conducted July 11, 2025; and expert interview 3, conducted July 10, 2025.

transition from forward presence to forward defenses in the Baltic.³⁸ These changes are recognized as being driven by the shock provoked by Russia’s aggression against Ukraine. From a Baltic standpoint, London’s renewed focus on reinforcing its role within NATO is commendable, as is its recognition that the alliance’s security threats are the ones that matter most to the United Kingdom. The country’s contribution to the defense of the Baltic region is seen in conjunction with that of the other militarily powerful NATO allies such as the United States, France, and Germany; their collective presence in the Baltic region sends “a powerful signal of political solidarity.”³⁹

In the nuclear realm, Russia’s nuclear signaling and aggressive rhetoric has prompted NATO to communicate more actively “that it is a nuclear alliance and that it maintains nuclear readiness”—a very positive evolution, from the Baltic perspective.⁴⁰ Extended nuclear deterrence remains a crucial element of overall Baltic security reassurance; in this regard, the United Kingdom’s capabilities are seen only as complements to U.S. and French nuclear capabilities. By their own assessment, the Baltic states are absolutely dependent on NATO to deter the Russian threat: “The Baltic states, with a combined population of about 6 million people, cannot deter Russia. Ukraine could not deter Russia, so why should we assume that we can deter Russia? NATO deters, not the Baltic states: for that purpose, the UK’s contribution is essential.”⁴¹ The key Baltic concern in the nuclear realm is the “paralyzing effect” Russian nuclear blackmail would have on decisionmakers and societies at large during a crisis—for instance, if Russia were to use sub-strategic, low-yield nuclear weapons against the alliance’s eastern flank. “The Russians probably feel quite confident that they will be able to dominate escalation psychologically,” and the Baltic states feel NATO’s deterrence against Russian nuclear use (in this specific scenario) is either not credible or not being credibly signaled.⁴²

The Baltic countries are concerned that NATO is not addressing their topmost priority urgently enough: filling the gaps in conventional capabilities and forces. “Every capability which helps NATO’s collective defense to be more credible—not only on paper, but also in reality—is always positive, but [the alliance’s] current focus should be how to be able to handle Russia in the next three to five years,” according to one expert interviewed, who added that the focus within Estonia, Latvia, and Lithuania is “on the war which is ongoing” and on “ensuring survival.”⁴³ In this regard, NATO’s military presence in the Baltic region is considered “insufficient”—especially if the United States follows through on its threat to withdraw troops from the region. The concern over the gaps in conventional capabilities relates to the alliance’s ability to repel a conventional Russian assault, which in turn impacts the effectiveness of NATO’s nuclear deterrence. Since “Russia still enjoys conventional superiority in this region,” the credibility of NATO’s nuclear deterrence against Russia is diminished, as is the effectiveness of allied reassurance efforts.⁴⁴ As further explored below, this criticism is pointed at the United Kingdom, among other allies.

THE REASSURANCE VALUE OF BRITISH ON-THE-GROUND PRESENCE

In all of the author’s conversations with Baltic security experts, a clear differentiation emerged between Estonia and the other two Baltic allies regarding the credibility of UK deterrence. This is in part because the United Kingdom acts as the framework nation for the NATO Forward Land Forces (FLF) battlegroup stationed in Estonia, through which 900 British personnel are permanently deployed—“ready to defend

38 Ibid.

39 Expert interview 2, conducted July 4, 2025.

40 Expert interview 1.

41 Expert interview 2.

42 Expert interview 1.

43 Expert interview 3.

44 Expert interview 2.

NATO's eastern flank" and "to deter aggression and uphold stability in eastern Europe," according to the Ministry of Defence.⁴⁵ Furthermore, the British Army's 4th Brigade Combat Team is currently held at high readiness, meaning thousands of additional troops are on standby and ready to be deployed to the region at short notice in the event of a crisis.⁴⁶ Estonia views the long-term, permanent, and operational nature of this bilateral engagement positively. Furthermore, one of the main talking points of Estonian officials when speaking about the British presence and commitment to the country is the fact that the United Kingdom is a nuclear power.⁴⁷ Military personnel from all three NATO nuclear powers being physically present in Estonia "certainly raises [the country's] level of assurance."⁴⁸

For the broader region, the United Kingdom's on-the-ground presence "most certainly" creates a linkage that increases its credibility when it commits its nuclear deterrent to the defense of NATO and, by extension, the Baltic countries.⁴⁹ This presence is perceived as an element that introduces uncertainty into Moscow's thinking as to how far London would go in responding to potential Russian aggression against the Baltic states, where its own troops are stationed. The United Kingdom's organizing and convening power, particularly its "visible, tangible, and practical" leadership role within the Joint Expeditionary Force (JEF)—consisting of the United Kingdom, the Netherlands, Denmark, Finland, Iceland, Norway, Sweden, Estonia, Latvia, and Lithuania—is seen as reinforcing this commitment and its overall image as a responsible security partner.⁵⁰ The JEF, established at the 2014 NATO summit, is one of alliance's flexible groups for "framework nations," which can include both member countries and non-NATO partners. Command and control for these groups are led by a specific nation (e.g., the United Kingdom in the case of the JEF) that aims to improve participating countries' "ability to operate together and helps solve burden sharing through bottom-up collaboration."⁵¹ Within this conventional arrangement, "the context remains of the UK being a nuclear power, but in the practical elements that is sometimes forgotten."⁵² The JEF is seen as a positive model for future smaller frameworks to follow in dealing with security and defense matters.

THE CREDIBILITY OF THE UK NUCLEAR DETERRENT

From a Baltic perspective, the United Kingdom's nuclear weapons contribute to the defense of Estonia, Latvia, and Lithuania only in conjunction with NATO's overall nuclear deterrence posture, which also includes U.S. and French nuclear capabilities. When its usefulness is assessed in conjunction with that of these two nuclear allies, the UK deterrent is seen as a potentially useful signaling tool during crisis. Public opinion in Estonia, Latvia, and Lithuania is increasingly aware and interested in nuclear matters in light of Russia's rhetoric, according to the interviewed experts, who recommended NATO issue a "more open explanation of what nuclear deterrence means" for both publics and officials in the Baltic states and the alliance more broadly as a means to increase reassurance.⁵³

45 "NATO's Military Presence in the East of the Alliance," NATO, updated June 6, 2025, https://www.nato.int/cps/en/natohq/topics_136388.htm; and UK Ministry of Defence, "10,000 UK Armed Forces Personnel Deployed Overseas to Keep Us Safe This Christmas," press release, December 22, 2024, <https://www.gov.uk/government/news/10000-uk-armed-forces-personnel-deployed-overseas-to-keep-us-safe-this-christmas>.

46 UK Ministry of Defence, "Britain Bolsters NATO's Eastern Flank with New Pact with Estonia and New Cooperation on Missile Defence," press release, October 17, 2024, <https://www.gov.uk/government/news/britain-bolsters-natos-eastern-flank-with-new-pact-with-estonia-and-new-cooperation-on-missile-defence>.

47 Expert interview 1.

48 Expert interview 3.

49 Ibid.

50 Expert interview 4.

51 Sean Monaghan, "The Joint Expeditionary Force: Global Britain in Northern Europe?," CSIS, *Commentary*, March 25, 2022, <https://www.csis.org/analysis/joint-expeditionary-force-global-britain-northern-europe>.

52 Expert interview 4.

53 Expert interview 3.

The UK nuclear deterrent's reassurance of Baltic allies is undermined by its perceived political unwillingness to use nuclear weapons during a potential crisis. The British on-the-ground presence in the Baltic states does not provide absolute nuclear reassurance in this regard, even for Estonia. In the words of one expert, "To what extent can we be confident that the UK would be willing to initiate nuclear war for the sake of defending a small ally in the outskirts of Europe? ... If push comes to shove, the one with character will prevail, and I'm afraid, at the moment, Moscow has character and London has considerations."⁵⁴ A different expert assessed British commitment as broadly credible, with the caveat that during a crisis it would have to be demonstrated—both to Baltic allies and to Russia itself. This uncertainty emanates from the UK arsenal's lack of flexible options that might be more suited for deterring or responding to the most likely nuclear scenario for the Baltic states: that of Russian sub-strategic, low-yield nuclear use against NATO's eastern flank. Nevertheless, due to Moscow's perception of the United Kingdom "as one of the culprits threatening Russia," the Baltic states do see British actions—and nuclear signaling more broadly—as having "more resonance in Moscow" and comparatively higher impact on its calculus than those of other key allies such as Germany.⁵⁵

Another factor undermining the credibility of UK reassurance is its perceived reluctance to invest in land-based capability or build a "more substantive force presence" in the Baltic region—particularly in the context of a potential reduction or withdrawal of U.S. conventional forces. Concerningly, British shortcomings in the conventional realm are seen as "a marker of a transient interest," signaling a lack of "depth" in the United Kingdom's commitment. British naval and air power are seen as flexible and easy to deploy but equally easy to withdraw, adding a substantive degree of uncertainty during a possible crisis: "There are questions [about] why such a powerful economic and technological power is not able to harness its own military resources and move at the speed of relevance."⁵⁶ As mentioned earlier, closing gaps in conventional capability is the utmost priority for the three Baltic allies, so they find this perceived lack of investment in and development of conventional capabilities for NATO's defense particularly unsettling. In the context of potential U.S. security disengagement from Europe and NATO, which the interviewed experts considered a real possibility, "some nuclear messaging" from the United Kingdom and France would be welcomed, but the key problem would remain in the conventional realm. "If the Russians would see NATO forces as able to defend the Baltic region and prevent a *fait accompli*, deterrence would work," said one expert, but this is not how Russia perceives the current conventional balance in the region, regardless of continued U.S. presence or withdrawal.⁵⁷

LONDON'S DECISION TO JOIN NATO'S NUCLEAR-SHARING ARRANGEMENTS

The 2025 SDR's recommendation to explore "enhanced UK participation in NATO's nuclear mission" was quickly put into action, with London announcing soon after its release that it would join NATO's nuclear burden-sharing arrangements.⁵⁸ The restoration of a low-to-intermediate-yield nuclear capability for the country stems from the understanding that its deterrent would be more credible and effective if it could "match Russian capabilities across an escalation ladder," as discussed above.⁵⁹ The interviewed Baltic security experts welcomed this development, commending London's decision as "adding credibility to the [NATO] deterrence posture," expanding the scale and geography of what

54 Expert interview 1.

55 Expert interview 2.

56 Expert interview 1.

57 Expert interview 2.

58 UK Ministry of Defence, *Strategic Defence Review*, 20; and Royal Air Force, "RAF F-35A."

59 Marion Messmer, "The UK Purchase of F35As Increases Reliance on US Systems – with Limited Benefits," Chatham House, June 27, 2025, <https://www.chathamhouse.org/2025/06/uk-purchase-f35as-increases-reliance-us-systems-limited-benefits>.

the alliance can do, and giving NATO planners additional options, as well as complicating Moscow's calculus due to the growing number of allies participating in the nuclear mission. The decision is in line with "demonstrating to the Russians that NATO is becoming more of a nuclear alliance," which the Baltic states see as necessary. In the case of the United Kingdom specifically, they see the DCA aircraft acquisition as augmenting the country's "limited" existing nuclear assets.⁶⁰

On the one hand, some commentary on this move has raised concerns over how this decision binds the United Kingdom "even closer" to the United States.⁶¹ Among nuclear-armed states, "the United Kingdom is unique in that its nuclear program is highly intertwined with that of another nuclear-armed state."⁶² Even though British strategic nuclear weapons are operationally independent and only the prime minister can authorize their use, the Trident submarine-launched ballistic missiles (SLBMs) are dependent on the United States for maintenance and support; furthermore, the two countries' warhead designs are believed to be "closely linked."⁶³ The possibility of any disruption in the bilateral relationship raises questions regarding its potential knock-on effects on the British nuclear deterrent and reassurance of allies.⁶⁴ The Baltic security experts interviewed shared this same concern, making specific reference to the United Kingdom's acquisition of F-35As: "Ukrainians have discovered this the hard way, and we might discover that as well: If our objectives do not align with U.S. policy and objectives, then such capabilities might have very little use."⁶⁵ However, London joining the nuclear mission at this time could be positive precisely because it ties the United States closer to Europe in a way that only the United Kingdom is equipped to do. From a Baltic perspective, this is in fact considered a uniquely British quality: "We see the UK as connecting Europe with the United States," making it an indispensable element in reinforcing transatlantic bonds.⁶⁶

On the other hand, the DCA acquisition could be understood as a stepping stone for the United Kingdom to again develop a sovereign air-leg nuclear capability that might offer more flexible options. The Baltic security experts interviewed considered this a potential long-term response to U.S. disengagement from NATO. They did point out that Russia might construe certain actions and developments as destabilizing, imposing "limits" on what the alliance can do, but that "we are not yet there—absolutely not."⁶⁷ Regardless, the development of new nuclear capabilities, although significant, is in no case the priority for Estonia, Latvia, and Lithuania; such long-term investment would require "time we currently don't have."⁶⁸

In the shorter term, the United Kingdom's decision could open the door for other European NATO allies to join the nuclear-sharing mission in coming years. The Baltic experts seemed positive about the prospect of Poland, for instance, doing so—an issue that has long been debated.⁶⁹ They understand

60 Expert interview 3.

61 Messmer, "The UK Purchase."

62 Hans M. Kristensen, Matt Korda, Eliana Johns, and Mackenzie Knight-Boyle, "United Kingdom Nuclear Weapons, 2024," *Bulletin of the Atomic Scientists* 80, no. 6 (2024): 394–407, <https://thebulletin.org/premium/2024-11/uk-nuclear-weapons-2024/>.

63 Marion Messmer and Olivia O'Sullivan, "The UK's Nuclear Deterrent Relies on US Support – but There Are No Other Easy Alternatives," Chatham House, March 24, 2025, <https://www.chathamhouse.org/2025/03/uks-nuclear-deterrent-relies-us-support-there-are-no-other-easy-alternatives>; and Kristensen et al., "United Kingdom Nuclear Weapons."

64 Héloïse Fayet, Andrew Futter, and Ulrich Kühn, "Forum: Towards a European Nuclear Deterrent," *Survival* 66, no. 5 (October–November 2024): 67–98, <https://www.iiss.org/online-analysis/survival-online/2024/09/forum-towards-a-european-nuclear-deterrent/>; and Messmer and O'Sullivan, "The UK's Nuclear Deterrent."

65 Expert interview 2.

66 Expert interview 4.

67 Expert interview 2.

68 Expert interview 3.

69 See, for instance, "Poland's Bid to Participate in NATO Nuclear Sharing," *Strategic Comments* 29, no. 7 (September 2023):

Poland's participation would be driven by "lessons learned" from Russia's aggression against Ukraine, deeming it perfectly justified in this pursuit given that it shares a border with a nuclear-armed adversary.⁷⁰ Although this would not have a direct impact on Baltic regional security, it would be a significant further step in NATO demonstrating to Russia that "actions have consequences."⁷¹

CONCLUSION

The views of Estonia, Latvia, and Lithuania on the United Kingdom's contribution to allied reassurance and deterrence against Russia demonstrate a clear overlap between their core security interests. The Baltic region does feel that NATO broadly has aligned more closely with their expectations as it has progressively better understood their security concerns. London's strong and institutionalized bilateral ties and engagement with the region through focused multilateral frameworks such as the JEF highlight its leadership and convening power, which these states regard very positively and as adding credibility to its commitment. The physical presence of allied troops, particularly British troops in Estonia, is recognized as a crucial part of allied reassurance and of overall deterrence against Russia. In the strictly nuclear realm, Baltic experts welcome the UK decision to join the NATO nuclear-sharing mission as a near-term enhancement of the alliance's deterrence posture.

The British nuclear deterrent, however, lacks credibility in Baltic eyes. It is seen only as a complement to U.S. and French deterrents, though it is nonetheless valued for its political and signaling features. Estonia, Latvia, and Lithuania—or at the very least their expert community—notice the limitations of the UK deterrent in potentially addressing the most likely shape of a future Russian threat against the Baltic region specifically. Furthermore, at a time when fears of U.S. disengagement are particularly acute, close U.S.-UK nuclear ties are seen as a vulnerability that undermines the benefits of the United Kingdom acquiring DCAs. Finally, and most crucially, London's declared commitment to the Baltic countries' deterrence is made uncertain by its conventional shortcomings, most notably its perceived lack of investment in this area and its avoidance of a more substantive force presence in the region.

The United Kingdom has much to gain in more clearly demonstrating to Baltic allies that it is invested in their defense and that its nuclear capabilities are a key component of its contribution to overall allied deterrence. Difficult choices lie ahead for British policymakers as the country continues to adapt its military capabilities to the new realities of European security. This paper hopes to have shed some light on the Baltic region's perspectives regarding what the direction of travel should be.

iv-vi, <http://doi.org/10.1080/13567888.2023.2258045>.

70 Expert interview 3.

71 Expert interview 2.



Scoping a European Approach to Damage Limitation

Drivers and Objectives

By Artur Honich¹

INTRODUCTION

For decades, damage limitation—the use of offensive and defensive measures to reduce the harm that an adversary’s nuclear capabilities can inflict on the United States and allies—has been an enduring objective of U.S. nuclear strategy.² Beyond the intent to reduce casualties and infrastructural devastation in the U.S. homeland in a hypothetical nuclear exchange, damage limitation is also designed to enhance the credibility of U.S. extended deterrence.³ This is achieved by signaling that the United States can defend its allies without losing the U.S. homeland to an adversary’s coercive

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- 1 Artur Honich is an analyst at RAND Europe. The views expressed in this paper are those of the author alone. The paper is not based on prior research conducted by RAND Europe, it does not represent RAND’s views or research findings, and it is not a statement of policy for any of RAND’s research sponsors. The author would like to thank Dr. Jacek Durkalec, Dr. Paul van Hooft, and Ellis Byrne for their valuable comments on early drafts of this paper, as well as Paul Cormarie, Dr. Matthew Costlow, Dr. Olivier Kempf, Etienne Marcuz, Tomáš Nagy, and Dr. Rishi Paul for their time and insights during the research interviews conducted for this essay.
 - 2 For an overview of the historical logic and feasibility of damage limitation through the Cold War, see Austin Long, “Damage Limitation in the 21st Century,” in *Counterforce in Contemporary U.S. Nuclear Strategy*, ed. Brad Roberts (Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, May 2025), 66–86, <https://cgsr.llnl.gov/sites/cgsr/files/2025-05/2025-0529-CGSR-Occasional-Paper-Counterforce-In-Contemporary-US-Nuclear-Strategy.pdf>.
 - 3 The most recent publicly available government document on this matter is the *2024 Report on the Nuclear Employment Strategy of the United States*, which states that President Biden’s Nuclear Weapons Employment Planning Guidance “reiterates the need to maintain counterforce capabilities to reduce potential adversaries’ ability to employ nuclear weapons against the United States and its allies and partners.” U.S. Department of Defense, *Report on the Nuclear Employment Strategy of the United States* (Washington, DC: U.S. Department of Defense, November 2024), 3, <https://media.defense.gov/2024/Nov/15/2003584623/-1/-1/1/REPORT-ON-THE-NUCLEAR-EMPLOYMENT-STRATEGY-OF-THE-UNITED-STATES.PDF>.

or retaliatory strikes.⁴ Therefore, damage limitation is intended to ensure that no U.S. president would ever have to “trade New York for Paris”—the often-cited core dilemma about the credibility of extended deterrence guarantees.⁵

Damage limitation is a primarily U.S. nuclear concept. In the European theater, despite the U.S. focus on limiting damage against Soviet (and later Russian) strategic nuclear capabilities that could reach the U.S. homeland, pursuing damage limitation against Russia’s nonstrategic nuclear weapons has not formed a central element of the contemporary nuclear strategy of the North Atlantic Treaty Organization (NATO).⁶ The concept is not part of the nuclear strategy of the other two nuclear-armed NATO allies, either: The United Kingdom and France have neither the stated requirement nor the nuclear force structure for a damage-limiting capability against Russian strategic or nonstrategic nuclear weapons at present.

This essay explores why the core logic of damage limitation could be relevant to the European theater and what key changes would be required to adapt the concept to the strategic needs of European NATO allies. This analysis is necessary due to a combination of external drivers (the scope and scale of the Russian missile threat) and internal developments (NATO’s ongoing adaptation process and anticipated shifts in burden sharing for European defense):

1. Russia has a broad and evolving suite of nuclear, dual-capable, and conventional ballistic missiles, cruise missiles, and hypersonic glide vehicles, as well as concepts for employing these capabilities to pursue war termination early in a hypothetical conflict with NATO.⁷
2. Russia has the willingness and capacity to conduct a protracted and large-scale strike campaign with missiles, guided bombs, and long-range drones against military and civilian targets. Further, Russia’s strike campaign against Ukraine reiterated that relying solely on defensive measures to counter missile threats is both operationally and financially unsustainable. This is due to the risk of saturation and also the cost imbalance between offensive effectors and the often comparatively more expensive interceptors.
3. Recent NATO and national decisions suggest that certain components of a damage limitation approach—or rather an adapted regional variation of the concept—are already emerging, but European leaders lack a holistic blueprint of what it should look like. Such developments include NATO’s new Integrated Air and Missile Defense (IAMD) Policy⁸; the prioritization of IAMD, deep strike capabilities and enablers in recent procurements and in NATO’s new

4 Vipin Narang and Pranay Vaddi, “How to Survive the New Nuclear Age: National Security in a World of Proliferating Risks and Eroding Constraints,” *Foreign Affairs*, June 24, 2025, <https://www.foreignaffairs.com/united-states/how-survive-new-nuclear-age-narang-vaddi>.

5 France’s General Charles De Gaulle famously raised this dilemma when meeting U.S. President John F. Kennedy in 1961. See “Memorandum of Conversation: President’s Visit, Paris, May 31–June 2, 1961,” in *Foreign Relations of the United States, 1961–1963*. Vol. 14, *Berlin Crisis, 1961–1962*, ed. Charles S. Sampson (Washington, DC: Government Publishing Office, 1993), Document 30, <https://history.state.gov/historicaldocuments/frus1961-63v14/d30>.

6 Jacek Durkalec, “Counterforce at the Regional Level of War: A European Perspective,” in *Counterforce in Contemporary U.S. Nuclear Strategy*, 152–67, <https://cgsr.llnl.gov/sites/cgsr/files/2025-05/2025-0529-CGSR-Occasional-Paper-Counterforce-In-Contemporary-US-Nuclear-Strategy.pdf>.

7 For detailed assessments of Russian concepts on nuclear employment and escalation management, see Michael Kofman et al., *Russian Military Strategy: Core Tenets and Operational Concepts* (Arlington, VA: Center for Naval Analyses, August 2021), <https://www.cna.org/reports/2021/08/Russian-Military-Strategy-Core-Tenets-and-Operational-Concepts.pdf>; and Dave Johnson, *Russia’s Conventional Precision Strike Capabilities, Regional Crises, and Nuclear Thresholds*, Livermore Papers on Global Security No. 3 (Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, February 2018), <https://cgsr.llnl.gov/sites/cgsr/files/2024-08/Precision-Strike-Capabilities-report-v3-7.pdf>.

8 “NATO Integrated Air and Missile Defence Policy,” NATO, February 13, 2025, https://www.nato.int/cps/en/natohq/official_texts_233084.htm.

capability targets⁹; and the growing conceptual focus on escalation management in allied capitals.

4. Lastly, NATO's burden sharing is undergoing a major shift as the second Trump administration has called on European NATO allies to take on a more significant share of Europe's conventional deterrence and defense. This demands a reflection on how Europeans would seek to defeat Russia's theory of victory with potentially less U.S. input.

These four drivers provide an opportunity to consider new concepts for existing and future capabilities as NATO continues to adapt and realign its posture in Europe. To explore how damage limitation—or a regional variation of it—could benefit NATO's European allies, the paper begins with an overview of the concept and its place in U.S. nuclear strategy. This is followed by an analysis of the external and internal drivers that should lead Europe to consider limiting damage against the Russian air and missile threat.

The paper concludes with a proposal to tailor the concept of damage limitation to the needs of European NATO allies and suggests three objectives for a regional damage limitation approach: (1) deter missile coercion scenarios, (2) absorb damage from Russia's initial missile attacks, and (3) manage escalation in the initial period of war.

THE CONCEPT OF DAMAGE LIMITATION AND ITS PLACE IN CONTEMPORARY U.S. NUCLEAR STRATEGY

For decades, the concept of damage limitation has been central to U.S. nuclear strategy, including the U.S. approach to extended deterrence. The concept dates to early Cold War–era deliberations about nuclear strategy and targeting policy.¹⁰ In a draft memorandum to President Lyndon B. Johnson dated November 1965, Secretary of Defense Robert McNamara argued that “assured destruction” and “damage limitation” should be the two “basic capabilities” for U.S. general nuclear war forces.¹¹ This document defined damage limitation as the ambition “to limit damage to our population and industrial capacity” in the event of deterrence failure (i.e., a nuclear attack on the United States or its allies).¹² The document also listed the capabilities that could be used for damage limitation, including anti-aircraft defenses, anti-ballistic missile defenses, anti-submarine defenses, and civil defense, as well as offensive forces such as nuclear-armed missiles and strategic bombers. Of note, the draft memorandum emphasized that “offensive forces are likely to remain the primary agent for limiting damage to our Allies.”¹³

Since then, the requirement for damage-limiting options has become a central feature of U.S. nuclear strategy.¹⁴ At its core, damage limitation seeks to achieve two imperatives: (1) the moral imperative

9 “NATO's Role in Capability Development,” NATO, June 26, 2025, https://www.nato.int/cps/en/natohq/topics_49137.htm.

10 Long, “Damage Limitation in the 21st Century.”

11 “Draft Memorandum from Secretary of Defense McNamara to President Johnson,” in *Foreign Relations of the United States, 1964–1968*. Vol. 10, *National Security Policy*, ed. David S. Patterson (Washington, DC: GPO, 2001), Document 103, <https://history.state.gov/historicaldocuments/frus1964-68v10/d103>.

12 Ibid.

13 Ibid.

14 Key aspects of this topic are covered in Brendan Rittenhouse Green, *The Revolution That Failed: Nuclear Competition, Arms Control, and the Cold War* (Cambridge, UK: Cambridge University Press, 2020); Lawrence Freedman and Jeffrey Michaels, *The Evolution of Nuclear Strategy*, 4th ed. (London: Palgrave Macmillan, 2019); K. Scott McMahon, *Pursuit of the Shield: The U.S. Quest for Limited Ballistic Missile Defense* (Lanham, MD: University Press of America, 1997); Andrew Futter, *Ballistic Missile Defence and US National Security Policy Normalisation and Acceptance After the Cold War* (Milton Park, UK: Routledge, 2013); and Long, “Damage Limitation in the 21st Century.”

of reducing harm from nuclear strikes to the population in the U.S. homeland and allied countries, in case strategic deterrence fails, and (2) the strategic imperative of deterring (further) nuclear escalation by undermining the adversary's confidence in their ability to inflict unacceptable damage against the United States.¹⁵ The latter is achieved by demonstrating that the United States could eliminate a sufficient portion of the adversary's nuclear forces such that the adversary could no longer inflict unacceptable retaliatory damage—therefore, the decision to escalate against the United States would only lead to worse outcomes for the adversary.¹⁶

Given long-standing U.S. alliance commitments, damage limitation has a special role in the U.S. approach to extended deterrence. The credibility of threatening nuclear war in defense of an ally is one of the thorniest challenges in both the theory and practice of deterrence.¹⁷ This core dilemma is summarized in French President Charles de Gaulle's famous question, when he asked U.S. President John F. Kennedy whether he would be "ready to trade New York for Paris."¹⁸ More recent alternative formulations of the same dilemma have been described as "Boston for Berlin" or "Washington for Warsaw."¹⁹ As British scholar Lawrence Freedman mused in 1982: "The United States would be irrational to commit suicide on behalf of Western Europe, but NATO has not found this fact a decisive flaw in its strategy."²⁰

The inherent credibility problem in risking national suicide to defend an allied country was not lost on U.S. decisionmakers. Consequently, U.S. extended deterrence strategy has become centered on convincing European allies that the United States could save them *without* losing the U.S. homeland to coercive or retaliatory Russian strikes.²¹ The concept has therefore been central to demonstrating that U.S. rhetoric about defending allies is underpinned by appropriate nuclear and conventional capabilities that reduce the chance of a U.S. president having to choose between saving Washington or Warsaw in the first place.²²

In the words of the senior Department of Defense official responsible for nuclear policy during the Biden administration: "The best deterrent to escalation is meaningful damage limitation capability at various levels that deters the adversary from miscalculating and further escalating the conflict, because we would be able to meaningfully limit the damage that they can impose on Europe and the U.S. homeland."²³

As shown in Table 1, damage limitation entails three main approaches, which involve four distinct missions.

15 Long, "Damage Limitation in the 21st Century," 66.

16 Ibid., 67.

17 Michael J. Mazarr, *Understanding Deterrence* (Santa Monica, CA: RAND, 2018), https://www.rand.org/content/dam/rand/pubs/perspectives/PE200/PE295/RAND_PE295.pdf.

18 "Memorandum of Conversation: President's Visit, Paris, May 31–June 2, 1961," in *Foreign Relations of the United States, 1961–1963*. Vol. 14, *Berlin Crisis, 1961–1962*, ed. Charles S. Sampson (Washington, DC: GPO, 1993), Document 30, <https://history.state.gov/historicaldocuments/frus1961-63v14/d30>.

19 Héloïse Fayet, Andrew Futter, and Ulrich Kühn, "Forum: Towards a European Nuclear Deterrent," *Survival* 66, no. 5 (2024), 69, <https://www.tandfonline.com/doi/full/10.1080/00396338.2024.2403218>; and Doug Bandow, "America's Relationship with Poland: Military Alliance or Social Club?," *The National Interest*, July 7, 2014, <https://nationalinterest.org/feature/americas-relationship-poland-military-alliance-or-social-10807>.

20 Lawrence Freedman, "NATO Myths," *Foreign Policy* 45 (Winter 1981), 50, <https://www.jstor.org/stable/pdf/1148309.pdf>.

21 Narang and Vaddi, "How to Survive the New Nuclear Age."

22 Pranay Vaddi and Vipin Narang, hosts, *Strategic Simplicity*, "Euro Deterrent, Part Deux: The Podcast Edition," Substack, April 3, 2025, <https://strategicsimplicity.substack.com/p/euro-deterrent-part-deux-the-podcast>.

23 Ibid., 13:50.

Table 1: Overview of Damage Limitation Approaches

Approach	Mission objectives (“ends”)	Relevant capabilities (“means”)
Counterforce	Destroy enemy weapon delivery vehicles before launch	Ballistic missiles, cruise missiles, aircraft-delivered gravity bombs
Strategic defense	Intercept enemy vehicles or their weapons after launch (active strategic defenses)	Sensors, aircraft and missile interceptors, command centers, communications links
	Avoid or withstand the effects of delivered weapons (passive strategic defenses)	Civil defense measures for populations (e.g., fallout shelters, radiological detection equipment, training and plans for evacuation), with other measures for critical infrastructure (e.g., hardening, camouflage, concealment, redundancy)
Escalation control (intra-war deterrence)	Constrain the scope, scale, and intensity of conflict and achieve war termination at the lowest level of damage possible	Plans and capabilities that credibly threaten further strikes against the adversary’s most valued assets (e.g., leadership, economic resources, military forces, command centers)

Source: Adapted from National Institute for Public Policy, *Section VI. Minimum Deterrence and Damage Limitation* (Fairfax, VA: National Institute for Public Policy, September 2014), 1–2, https://www.esd.whs.mil/Portals/54/Documents/FOID/Reading%20Room/Litigation_Release/Litigation%20Release%20-%20Section%20VI%20Minimum%20Deterrence%20Damage%20Limitation.pdf.

Several recent strategic documents outline the importance of damage limitation in contemporary U.S. nuclear strategy. The Biden administration’s 2024 Report on the Nuclear Employment Strategy of the United States instructed Department of Defense planners to “seek to end any conflict at the lowest level of damage possible,” reiterating the language used in the first Trump administration’s 2020 nuclear employment strategy.²⁴ The 2024 document also emphasized “the need to maintain counterforce capabilities to reduce potential adversaries’ ability to employ nuclear weapons against the United States and its allies and partners.”²⁵ Further, the 2022 Missile Defense Review noted that “missile defenses can help mitigate damage to the homeland and help protect the U.S. population.”²⁶ The same document committed the United States to “improve its full spectrum of missile defeat capabilities,” including efforts to counter “the development, acquisition, proliferation, potential and actual use of adversary offensive missiles of all types, and to limit damage from such use.”²⁷

EXTERNAL AND INTERNAL DRIVERS OF THE NEED FOR DAMAGE LIMITATION

This section outlines how NATO’s evolving strategic environment shapes the relevance of damage limitation, addressing both external threat factors and internal dynamics. This is necessary to understand which parts of the concept could apply to the European theater and which elements would require adaptation.

EXTERNAL DRIVER: THE RUSSIAN MISSILE THREAT

The Russian missile threat to NATO is increasing in scope and scale. Russia maintains a broad and evolving suite of nuclear, dual-capable, and conventional ballistic missiles, cruise missiles, and

24 U.S. Department of Defense, *Report on the Nuclear Employment Strategy of the United States*, 3.

25 Ibid.

26 U.S. Department of Defense, *2022 Missile Defense Review* (Washington, DC: DOD, 2022), 6, <https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.PDF>.

27 Ibid., 1, 6.

hypersonic glide vehicles with varying ranges and payloads that can be launched from ground-, air-, and sea-based platforms against military, critical infrastructure, and civilian targets across Europe.²⁸ The exact quantities and types of missiles are not available in open sources. While it cannot be independently verified, a June 2025 estimate published by Ukraine's military intelligence service mentions an inventory of 1,950 ballistic and cruise missiles of the types regularly used to strike Ukraine.²⁹ It is clear that this list does not include estimates for Russia's intermediate- and intercontinental-range missiles, which could also be used to target Europe. A recent report estimated that Russia may be able to produce 200 medium- and intermediate-range ballistic missiles by 2030.³⁰

Russian operational concepts for these long-range strike capabilities emphasize preemption at the onset of a conflict to destroy or at least degrade NATO airpower.³¹ Russia is aware of its conventional inferiority to NATO, and its concepts reflect a desire to avoid facing the alliance's collective military power in a protracted conventional war. Analysis of Russian military expert discourse before the full-scale invasion of Ukraine underscored the perceived importance of the initial period of war. In this phase, Russia would seek to deflect NATO's airpower while conducting strategic attacks to degrade and disorganize the alliance and attain war termination if possible.³² Offensive tasks for Russia's strategic nonnuclear capabilities are understood to focus on eliminating NATO's ability to fight a war against Russia by destroying its missile launch platforms, air and missile defenses, command and control systems, and other critical infrastructure short of nuclear escalation.³³ A related key Russian concept is the "strategic operation for the destruction of critically important targets" (SODCIT), which envisions undermining the opponent's will to fight by attacking various military, economic, and political-administrative targets (including through non-kinetic attacks).³⁴

More recent analysis of Russian operational concepts shows that more than three years of fighting against Ukraine have not meaningfully shifted Russian thinking about the importance of the initial period of war and the preemptive role of long-range strikes. As researchers at the Center for Naval Analyses concluded, Russia's theory of victory involves "deploying rapid and overwhelming force during the Initial Period, imposing costs via strategic defense and long-range strikes, maintaining escalation dominance, and undermining the adversary's will to fight."³⁵ This assessment was echoed in the 2024 Senate testimony of General Gregory M. Guillot, commander of U.S. Northern Command and North American Aerospace Defense Command, who stated that Russia plans to use a diverse set

28 For an overview of Russia's nuclear capabilities, see Hans M. Kristensen, Matt Korda, Eliana Johns, and Mackenzie Knight, "Russian Nuclear Weapons, 2025," *Bulletin of the Atomic Scientists* 81, no. 3 (2025): 208–37, <https://doi.org/10.1080/00963402.2025.2494386>. For an overview of Russia's nonnuclear missile capabilities, see Clint Reach et al., *Russia's Evolution Toward a Unified Strategic Operation: The Influence of Geography and Conventional Capacity* (Santa Monica, CA: RAND, 2023), https://www.rand.org/pubs/research_reports/RRA1233-8.html. For a specific assessment of Russian missile threats against the United Kingdom, see Sidharth Kaushal, *An Integrated Air and Missile Defence Architecture for the UK: Options to Defend the UK from the Russian Missile Threat* (London: RUSI, August 2025), https://static.rusi.org/integrated-air-and-missile-defence-architecture-for-uk_0.pdf.

29 Uliana Bezpalko and Oleksandra Bashchenko, "Russia's Weapons Stockpile Revealed: How Many Missiles and Drones Are Left?," RBC-Ukraine, June 21, 2025, <https://newsukraine.rbc.ua/news/russia-s-weapons-stockpile-revealed-how-many-1750496990.html>.

30 Kaushal, "An Integrated Air and Missile Defence Architecture for the UK," 12.

31 Clint Reach, Alexis A. Blanc, and Edward Geist, *Russian Military Strategy: Organizing Operations for the Initial Period of War* (Santa Monica, CA: RAND, 2022), https://www.rand.org/pubs/research_reports/RRA1233-1.html; and Michael Petersen, Paul Schwartz, and Gabriela Iveliz Rosa-Hernandez, *Russian Concepts of Future Warfare Based on Lessons from the Ukraine War* (Arlington, VA: Center for Naval Analyses, July 2025), <https://www.cna.org/reports/2025/08/Russian-Concepts-of-Future-Warfare-Based-on-Lessons-from-the-Ukraine-War.pdf>.

32 For a detailed overview of relevant Russian operational concepts, see Kofman et al., *Russian Military Strategy*.

33 Reach et al., *Russia's Evolution Toward a Unified Strategic Operation*, iii.

34 Kofman et al., *Russian Military Strategy*, 68–69.

35 Petersen et al., *Russian Concepts of Future Warfare Based on Lessons from the Ukraine War*, 72.

of nonnuclear capabilities such as cyber weapons and conventionally armed air-, sea-, and ground-launched cruise missiles “to strike Western economic and military infrastructure in an attempt to degrade our political will and compel negotiations to terminate an escalating conflict.”³⁶

While the expert discourse often focuses on the potential role of Russia’s nonstrategic nuclear weapons in escalation management, it is important to understand the distinct threat of conventional missile coercion against NATO, given both the capabilities and concepts Russia has for such a scenario. Ultimately, no analysis of Russian expert discourse can guarantee how Russia would pursue the initial phase of war in a hypothetical conflict. Therefore, NATO must prepare to deter or, if deterrence fails, manage escalation against Russia, whether Russia seeks war termination employing solely conventional capabilities or conducts a strike campaign against NATO that blends conventional and nonstrategic nuclear forces.

INTERNAL DRIVER: NATO’S ADAPTATION AMID ANTICIPATED SHIFTS IN BURDEN SHARING

Since Russia launched its aggression against Ukraine in 2014, NATO has implemented comprehensive measures to adapt and bolster its deterrence and defense posture, including its nuclear deterrence.³⁷ Since June 2020, the Concept for Deterrence and Defence of the Euro-Atlantic Area (DDA) has served as the foundation of NATO’s approach to collective defense.³⁸ The implementation of DDA has led to a new strategic plan for the defense of the alliance’s area of responsibility, new regional and domain-specific plans, and a new NATO Force Model.³⁹ Based on the approved plans, NATO allies agreed to new capability targets in June 2025, which prioritize IAMD, conventional long-range weapons, logistics, and large land maneuver formations.⁴⁰

Further investments in IAMD, conventional strike capabilities, and relevant enablers are essential and urgent because NATO’s internal burden sharing is expected to undergo major shifts under the second Trump administration. In February 2025, Secretary of Defense Pete Hegseth announced that the administration expects European allies to “step into the arena and take ownership of conventional security on the continent.”⁴¹ In late March, media reporting on the administration’s Interim National Defense Strategic Guidance stated that while the United States would continue to extend its nuclear deterrence to European allies, conventional support to Europe may be reduced.⁴²

As of mid-October 2025, the Trump administration had not set forth any major decisions on U.S. force posture in Europe, though European officials had been anticipating an announcement about

36 Statement of General Gregory M. Guillot, Commander of United States Northern Command and North American Aerospace Defense Command (Senate Armed Services Committee, March 14, 2024), 7, https://www.armed-services.senate.gov/imo/media/doc/guillot_statement_31424.pdf.

37 See Jeffrey A. Larsen, “NATO Nuclear Adaptation Since 2014: The Return of Deterrence and Renewed Alliance Discomfort,” *Journal of Transatlantic Studies* 17, no. 1 (2019), 174–93, <https://doi.org/10.1057/s42738-019-00016-y>.

38 For an unclassified overview of this document, see Stephen R. Covington, “NATO’s Concept for Deterrence and Defence of the Euro-Atlantic Area (DDA),” Belfer Center for Science and International Affairs, Harvard Kennedy School, August 2, 2023, <https://www.belfercenter.org/publication/natos-concept-deterrence-and-defence-euro-atlantic-area-dda>.

39 Ibid.

40 “NATO’s Role in Capability Development,” NATO.

41 Pete Hegseth, “Opening Remarks by Secretary of Defense Pete Hegseth at Ukraine Defense Contact Group (As Delivered),” U.S. Department of Defense, February 12, 2025, <https://www.defense.gov/News/Speeches/Speech/Article/%204064113/opening-remarks-by-secretary-of-defense-pete-hegseth-at-ukraine-defense-contact/>.

42 Alex Horton and Hannah Natanson, “Secret Pentagon Memo on China, Homeland Has Heritage Fingerprints,” *Washington Post*, March 29, 2025, <https://www.washingtonpost.com/national-security/2025/03/29/secret-pentagon-memo-hegseth-heritage-foundation-china/>.

the withdrawal of certain U.S. conventional capabilities for several months.⁴³ If European allies must fill capability gaps or mitigate them through alternative measures, the role of the United Kingdom and France, as Europe's only two nuclear-armed states, could be crucial. Additionally, national procurements, as well as joint projects such as the European Long-Range Strike Approach (ELSA) and the European Sky Shield Initiative (ESSI), provide opportunities for nonnuclear European allies to field conventional long-range strike and missile defense systems that could be part of a future European damage limitation approach.⁴⁴

Another key development in the NATO context is the alliance's new IAMD Policy, endorsed by NATO defense ministers in February 2025.⁴⁵ This document represents a key milestone in NATO's conceptual thinking, and the links to the concept of damage limitation are clearly visible. The document names Russia as the main source of air and missile threats to NATO and proposes four "effects" to guide the implementation of NATO IAMD: no threat, no launch, no impact, and no consequences.⁴⁶

While this document states that NATO IAMD is "tailored to address all air and missile threats emanating from all strategic directions from state and non-state actors," it does not contain an explicit ambition to limit damage against Russia's nuclear capabilities.⁴⁷ However, three of these four "effects" are closely aligned with the three damage limitation objectives listed in Table 1: The "no launch" effect may be achieved through offensive operations to destroy missile threats left of launch; the "no impact" effect relies on interception via active air and missile defenses; and the "no consequences" effect relies on passive defenses for populations and critical infrastructure. The emergence of such concepts in the NATO context can support wider discussions about why a European approach to damage limitation could be necessary and what it could look like.

DEFINING THE CONTOURS OF A EUROPEAN APPROACH TO DAMAGE LIMITATION

NUCLEAR COUNTERFORCE IS BEYOND EUROPE'S REACH

When considering how European NATO allies might adopt the concept of damage limitation, an immediate constraint must be addressed. As described above, the U.S. approach to the concept requires a mix of nuclear and conventional capabilities to hold at risk a significant share of the adversary's strategic nuclear forces. Since all but two European NATO allies are nonnuclear-weapon states, this poses inherent limitations concerning European capabilities that could be assigned to the offensive pillar of the concept.

43 For example, Alexandra Brzozowski, "European NATO Allies Begin to Brace for US Troops Posture Rethink," *Euractiv*, July 3, 2025, <https://www.euractiv.com/section/defence/news/european-nato-allies-begin-to-brace-for-us-troops-posture-rethink/>; House of Commons Defence Committee, *The UK Contribution to European Security* (oral evidence, Luke Pollard MP, Minister for the Armed Forces, July 8, 2025), HC 2024–26, No. 520, Question 299, <https://committees.parliament.uk/oralevidence/16273/html/>; and Chris Lunday, "Berlin Left in the Dark as Washington Weighs Troop Cuts in Europe," *Politico*, July 28, 2025, <https://www.politico.eu/article/germany-guessing-trump-us-troop-cuts-europe-military-defense-pete-hegseth-boris-pistorius-nato/>.

44 For an overview of ELSA and a list of European long-range conventional precision-strike capabilities, see Timothy Wright, "Europe's Missile Renaissance," International Institute for Strategic Studies, November 25, 2024, <https://www.iiss.org/online-analysis/online-analysis/2024/11/europes-missile-renaissance/>; for an overview of ESSI members and their air and missile defense capabilities, see Sibel Düz and Muhammed Sefa Koçakoğlu, *European Sky Shield Initiative: Capacities, Criticisms, and Türkiye's Contribution* (Ankara: SETA, February 2025), <https://media.setav.org/en/file/2025/02/europe-an-sky-shield-initiative-capacities-criticisms-and-turkiyes-contribution.pdf>.

45 "NATO Integrated Air and Missile Defence Policy," NATO.

46 *Ibid.*, paragraph 23.

47 *Ibid.*, paragraph 5.

Neither the United Kingdom nor France has the stated requirement or the nuclear force structure for a damage-limiting capability against Russian strategic or nonstrategic nuclear weapons. These states have considerably fewer nuclear warheads than the United States, have not declared sub-strategic yields, and do not have as many launch platforms as the United States.⁴⁸ For example, the UK nuclear deterrent is based solely on submarine-launched ballistic missiles at present—the deliveries of the newly purchased nuclear-certified F-35A aircraft will only start “before the end of the decade.”⁴⁹ Crucially, France’s defense strategy entirely rejects the notion of nuclear counterforce targeting.⁵⁰

Therefore, adopting the original damage limitation concept would require the United Kingdom and France to completely reorient their nuclear doctrine and redesign their nuclear force structures. This is not realistic for political and financial reasons, not least because it would likely require decades to implement.

ADAPTING THE CONCEPT OF DAMAGE LIMITATION TO EUROPE’S REALITIES

If Europe’s two nuclear powers and nonnuclear European allies do not currently have and cannot field a suite of damage limitation capabilities holding Russia’s strategic nuclear forces at risk within a reasonable time frame, what alternative approaches could be considered? This paper argues that in the present strategic environment, European NATO allies should field capabilities that can limit damage against Russia’s nonstrategic, dual-capable, and conventional missiles. This proposal builds on recent scholarship, particularly a paper by Jacek Durkalec, who suggests that NATO adopt a regional counterforce strategy against Russian nonstrategic nuclear weapons through a mix of nuclear and nonnuclear capabilities.⁵¹

This essay advances this point by arguing that, in addition to holding a portion of Russian nonstrategic nuclear weapons at risk, European NATO allies should also target Russia’s conventional and dual-capable missiles while strengthening IAMD capabilities that can counter missile coercion scenarios. A European regional damage limitation strategy should have three main objectives: (1) deter missile coercion scenarios, (2) absorb damage from Russia’s initial missile attacks, and (3) manage escalation in the initial period of war.

▪ Deter missile coercion scenarios.

As discussed above, Russia has both concepts and capabilities for attempting a missile coercion scenario in a developing crisis with NATO. The intent behind this would be to compel the alliance or key NATO allies to surrender through calibrated strikes on military or symbolic targets. The intended effect of such attacks would be to convince the target that continued resistance against Russia would be detrimental to their interests.⁵²

48 Névine Schepers, *Debating Nuclear Deterrence in Europe*, CSS Analyses in Security Policy, No. 356 (Zurich: CSS, March 2025), <https://css.ethz.ch/content/dam/ethz/special-interest/gess/cis/center-for-securities-studies/pdfs/CSSAnalyse356-EN.pdf>.

49 House of Commons Defence Committee, *The Work of the Secretary of State for Defence* (oral evidence of John Healey MP, Secretary of State for Defence, July 2, 2025), HC 2024–26, No. 973, Question at 18, <https://committees.parliament.uk/oralevidence/16226/html/>.

50 Corentin Brustlein, “Alliance Security and the Role of Nuclear Counterforce: A French View,” in *Counterforce in Contemporary U.S. Nuclear Strategy*, ed. Brad Roberts (Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, May 2025), 168–88.

51 Durkalec, “Counterforce at the Regional Level of War: A European Perspective,” 152–67. See also a report that argues for increasing European investments into advanced conventional weapons: Paul van Hooft and Davis Ellison, *Good Fear, Bad Fear: How European Defense Investments Could Be Leveraged to Restart Arms Control Negotiations with Russia* (The Hague: Hague Center for Strategic Studies, 2023), <https://hcss.nl/report/good-fear-bad-fear-how-european-defence-investments-could-be-leveraged-to-restart-arms-control-negotiations-with-russia/>.

52 Congressional Commission on the Strategic Posture of the United States, *America’s Strategic Posture: The Final Report of*

Russian attempts to coerce European states could involve exclusively conventional weapons; nonstrategic nuclear weapons are not inherently part of such a scenario. For instance, following the demonstrative Oreshnik attack against the Ukrainian city of Dnipro in November 2024, Russian strategic communications quickly emphasized that the missile was intended to induce caution in European capitals, including the nuclear-armed United Kingdom and France.⁵³ In a future crisis, Moscow would most likely seek to decouple the United Kingdom and France from nonnuclear European allies on NATO's Eastern Flank, akin to long-standing Soviet/Russian ambitions to decouple the United States from Europe.

NATO must deny Russia the temptation to coerce Europeans with conventional and nuclear missile threats. This requires a damage limitation approach against both conventional missile threats and nonstrategic nuclear weapons to prevent the alliance from being blackmailed at various levels of conflict. Of course, it is not possible to entirely deny Russia the ability to strike NATO targets.

Instead, efforts aimed at deterring missile coercion should be based on deterrence by denial, making it harder for Russia to achieve the same goal while seeking to reduce the damage Russia would seek to inflict. Accepting the assumption that such missile coercion scenarios would primarily be preemptive attacks by Russia, the capabilities relevant to this objective are mainly active and passive missile defenses. By fielding more defensive systems, NATO allies would force Russia to increase the number of missiles assigned to any coercive attack. However, the more capabilities Russia would need to employ, the less "limited" such an attack would be perceived. This might leave the targeted nation with no choice but to respond.

Therefore, NATO should seek to create more uncertainty for Russian decisionmaking about whether a coercive missile raid would succeed while also increasing the risk that any Russian attempt to compel surrender may achieve the opposite outcome. Fielding air and missile defense systems can have this deterrent effect by complicating Russia's risk calculus about whether such an attack would succeed and what response it might trigger.

- **Absorb damage from Russia's initial missile attacks.**

While the best time to neutralize a missile threat is prior to its launch, NATO may face political constraints when it comes to offensive options against Russian missile threats in a developing crisis. Given the defensive mandate of the alliance, it is difficult to imagine NATO would reach a consensus on conducting preemptive strikes against Russian missile launchers even if the alliance had the indicators and warnings of an imminent Russian attack. Further, NATO should also consider the possibility that, despite its best efforts, the objective of deterring missile coercion scenarios might fail—in which case the alliance would have to withstand such an attack.

the Congressional Commission on the Strategic Posture of the United States (Alexandria, VA: Institute for Defense Analyses, October 2023), 66, <https://www.ida.org/research-and-publications/publications/all/a/am/americas-strategic-posture>.

53 Sidharth Kaushal and Matthew Savill, "The Oreshnik Ballistic Missile: From Russia with Love?," RUSI, *Commentary*, December 10, 2024, <https://www.rusi.org/explore-our-research/publications/commentary/oreshnik-ballistic-missile-russia-love>; "Oreshnik Test Launch Forces London to Take a Step Back—Russian Ambassador," TASS, December 18, 2024, <https://tass.com/politics/1889373>; and Preston Stewart (@prestonstew_), "Russian media released a new graphic showing Oreshnik missile flight times to major cities in Europe," X, November 22, 2024, 5:48 a.m., https://x.com/prestonstew_/status/1859941991754441011.

Therefore, the second objective for a European regional damage limitation approach should be to help absorb Russia's initial missile attack, whether part of a missile coercion scenario or SODCIT attacks against military and critical infrastructure in the initial period of war.

Notably, this objective provides sufficient flexibility to account for different perspectives among European allies. For example, while smaller nations may consider fielding active missile defenses that can provide a limited capability for protecting population centers, France can maintain its long-held doctrinal position of not limiting damage to its population centers. Instead, France may focus on enhancing the protection of strategic sites such as submarine bases and air bases stationing nuclear-capable Rafale aircraft.

Once again, this second objective is not to suggest that Europe can become invulnerable to Russian saturation attacks, as Russia will have the means to overwhelm defensive measures. However, if NATO can demonstrate an improved ability to absorb damage against Russian missile strikes, this could strengthen perceptions about the alliance's resolve to stand firm in a crisis. Further, the more missile capabilities Russia needs to employ to achieve the stated objectives of its concepts, the greater the risk of escalation. This leads to the third area where a European regional damage limitation approach should seek to deny Russia's theory of victory.

- **Manage escalation in the initial period of war.**

The third objective for a European regional damage limitation approach should be to signal to Russia that NATO can manage escalation and deny Russia's path to victory. Russia is expected to escalate a conflict if it perceives this would help achieve its objectives and compel NATO to accept a new status quo. Therefore, NATO needs to field offensive capabilities that can hold at risk Russia's ability to achieve its war aims: its missile capabilities, command and control, air defense, logistics, and critical infrastructure in Kaliningrad and Russia's European territory.

Given Russia's integration of conventional and nuclear capabilities, as well as the use of strategic systems for warfighting (e.g., the use of strategic bombers against Ukraine), the offensive pillar of damage limitation would also have to hold at least a portion of these targets at risk. As Durkalec argued, regional counterforce "could counterbalance Russia's perception of escalation dominance at the regional level" and could produce a "net benefit" for strategic stability with Russia.⁵⁴ Bolstering European conventional precision strike capabilities would also ensure European NATO allies have more options in case the United States were embroiled in a multi-theater contingency.⁵⁵

Increasing conventional damage-limiting capabilities could also contribute to NATO's nuclear mission. For example, fielding more ground-based long-range fires could reduce pressures on NATO's dual-capable aircraft, which otherwise might face concurrent operational demands between conventional strike missions and conventional support for nuclear operations.⁵⁶ Strengthening NATO's nuclear mission would bolster deterrence aimed at preventing conflict in the first place and, if deterrence fails, serve as a credible escalation management option in itself.

54 Durkalec, "Counterforce at the Regional Level of War: A European Perspective," 165–67.

55 Astrid Chevreuil, "European Deterrence at a Crossroads: French and British Nuclear Options," *Washington Quarterly* 48, no. 2 (2025), 119, <https://www.tandfonline.com/doi/full/10.1080/0163660X.2025.2514975#d1e141>; and Paul van Hooft and Davis Ellison, *Good Fear, Bad Fear*.

56 William Alberque and Artur Kacprzyk, "More Pillars Needed: Ten Options for Europe to Improve NATO's Nuclear Deterrence," Stimson Center, October 2, 2024, <https://www.stimson.org/2024/more-pillars-needed-nato-nuclear-deterrence/>.

NEXT STEPS FOR IMPLEMENTATION: IDENTIFY OPERATIONAL REQUIREMENTS AND FILL CAPABILITY GAPS

This paper provided an overview of the U.S. concept of damage limitation, analyzed the external and internal drivers that make the concept relevant for European NATO allies, and described how the original concept should be tailored to the specific circumstances of the European theater to limit damage against Russia's nonstrategic, dual-capable, and conventional missiles.

Notwithstanding recent and ongoing developments aimed at strengthening long-range strike capabilities and IAMD within NATO, the operationalization of the three proposed objectives would still require considerable time and investment. It is beyond the scope of this paper to provide detailed requirements and a timeline for implementation, partly because these must be informed by classified assessments about Russia's missile capabilities and perceptions of damage thresholds.

Instead, this paper concludes with a list of key considerations that would be central to implementing the concept:

- Most importantly, can and should a European regional damage limitation concept rely on U.S. strategic enablers for both its defensive and offensive pillars, given present dependencies?⁵⁷
- To what extent should the concept entail holding at risk some of the strategic nuclear forces (e.g., strategic bombers) that Russia could employ against NATO in a conventional role or for limited nuclear use?
- What targets will NATO allies seek to defend against Russian missile threats, and how much damage are they willing to absorb? The answer will drive IAMD requirements.
- What should be the appropriate mix of offensive and defensive capabilities in a regional damage limitation approach?
- How will European allies share the burden of fielding the offensive capabilities as part of a regional damage limitation approach? ELSA, various national procurements, and ongoing bilateral projects (e.g., the UK-French Future Cruise / Anti-Ship Weapon and renewed production of SCALP and Storm Shadow missiles, and the UK-German joint deep precision strike project with a range of 2,000 km) will not only bolster offensive options but also spread the burden and complicate Moscow's risk calculus and operational plans, given the increasing number of European decisionmaking centers that possess advanced conventional counterforce capabilities.⁵⁸
- What damage-limiting role could future theater nuclear capabilities—such as a novel standoff capability for NATO's nuclear sharing or the United Kingdom's hypothetical return to a sovereign air leg—play?

57 For a comprehensive assessment, see "Chapter One: Fixing Europe's Hardware Gaps" in *Progress and Shortfalls in Europe's Defence: An Assessment*, ed. James Hackett and Ben Schreer (London: International Institute for Strategic Studies, September 2025), 9–21, <https://www.iiss.org/publications/strategic-dossiers/progress-and-shortfalls-in-europes-defence-an-assessment/>.

58 UK Prime Minister's Office, "Lancaster House 2.0: Declaration on Modernising UK-French Defence and Security Cooperation," press release, July 10, 2025, <https://www.gov.uk/government/news/lancaster-house-20-declaration-on-modernising-uk-french-defence-and-security-cooperation>; and UK Ministry of Defence, "New 2,000 Km 'Deep Precision Strike' Weapon to Be Developed by UK and Germany as Trinity House Agreement Delivers First Major Milestones," press release, May 15, 2025, <https://www.gov.uk/government/news/new-2000-km-deep-precision-strike-weapon-to-be-developed-by-uk-and-germany-as-trinity-house-agreement-delivers-first-major-milestones>.



Review of the Debate Over U.S. Nuclear Weapons in South Korea

By Jaclyn Schmitt¹

INTRODUCTION

Much of today's nuclear policy discourse focuses on the emergence of two U.S. nuclear peer competitors: China and Russia. The 2022 National Defense Strategy and 2022 Nuclear Posture Review cite the People's Republic of China as the "overall pacing challenge for U.S. defense planning" and Russia as the "acute threat."² However, North Korea also poses a growing threat to the United States and its allies and partners in the Indo-Pacific region, particularly the Republic of Korea (ROK).

North Korea has increased tensions on the Korean Peninsula not only by conducting weapons tests but also by taking policy measures to challenge the status quo and threaten U.S. and allied military posture. For example, North Korea has adopted a more aggressive nuclear posture and pushed the development of tactical nuclear weapons (TNWs).³ North Korean leader Kim Jong-un also met with Russian President Vladimir Putin in June 2024 to sign a strategic partnership treaty and strengthen

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 - 2 U.S. Department of Defense, *2022 Nuclear Posture Review* (Washington, DC: U.S. Department of Defense, 2022), 4; and U.S. Department of Defense, *2022 National Defense Strategy* (Washington, DC: U.S. Department of Defense, 2022), 5, <https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.pdf>.
 - 3 Daniel M. Gettinger and Mary Beth Nikitin, "North Korea's Nuclear Weapons and Missile Programs," Congressional Research Service, IF10472, September 26, 2025, <https://www.congress.gov/crs-product/IF10472>; "Law on DPRK's Policy on Nuclear Forces Promulgated," KCNA Watch, September 9, 2022, <https://kcnawatch.org/newstream/1662687258-950776986/law-on-dprks-policy-on-nuclear-forces-promulgated/>; and Ellen Kim, "North Korea States It Will Never Give Up Nuclear Weapons," CSIS, *Critical Questions*, September 9, 2022, <https://www.csis.org/analysis/north-korea-states-it-will-never-give-nuclear-weapons>.

bilateral strategic cooperation.⁴ As of November 2024, Kim Jong-un had sent an estimated 11,000 to 12,000 North Korean troops to Russia.⁵

South Korea depends on the U.S. nuclear umbrella to deter North Korea. In response to these new security threats, South Korea and the United States have taken significant steps toward strengthening extended deterrence. In April 2023, U.S. President Joe Biden and South Korean President Yoon Suk Yeol issued the Washington Declaration, in which the presidents reaffirmed their extended deterrence and nonproliferation commitments and established the Nuclear Consultative Group (NCG) to deepen their nations' mutual defense relationship.⁶

However, given North Korea's weapons advancements and increasing cooperation with Russia, some South Koreans do not think these expanded deterrence efforts are sufficient. Many have suggested redeploying U.S. TNWs to South Korea to improve deterrence and assurance on the Korean Peninsula, but many also oppose this option, saying the negative consequences would outweigh the potential benefits. This review paper compares arguments for and against redeploying TNWs to, or entering a nuclear-sharing agreement with, South Korea and identifies promising areas for future work. An assessment of the arguments themselves is beyond the scope of this work.

THE NORTH KOREAN THREAT

To understand the potential deterrence benefits of TNWs in South Korea, it is critical to first understand the history of North Korea's nuclear program, the threats it perceives, and its national security goals and strategy.

NORTH KOREAN NUCLEAR PROGRAM

North Korea established its nuclear weapons program in the 1950s with the help of the Soviet Union and has been advancing it ever since, despite continuous multinational efforts to end the program. Since the 1990s, the United States, South Korea, and other countries have made agreements with North Korea that usually exchange some form of energy or other humanitarian assistance for North Korea's promise to terminate its nuclear weapons program.

North Korea has never fully followed through on any of these agreements and continues to advance its nuclear weapons program. A 2021 public assessment of North Korea by the Defense Intelligence Agency (DIA) states North Korea has conducted six nuclear tests and has developed a variety of ballistic missiles.⁷ North Korea's intercontinental ballistic missiles (ICBMs) likely could reach the United States, which raises the question of whether the United States would be willing to come to South Korea's aid when North Korea could retaliate with a nuclear attack on the United States.

NORTH KOREAN THREAT PERCEPTION AND STRATEGY

According to the DIA, the primary threat North Korea perceives is the United States, due to its role in the Korean War, its continued military presence in South Korea, and its attempts to inhibit North

4 Hyonhee Shin, "Key Points of North Korea, Russia Landmark Strategic Partnership Treaty," Reuters, June 20, 2024, <https://www.reuters.com/world/asia-pacific/key-points-north-korea-russia-landmark-strategic-partnership-treaty-2024-06-20/>.

5 Jim Garamone, "Pentagon Says 10K North Korean Troops in Kursk Oblast," DOD News, November 4, 2024, <https://www.defense.gov/News/News-Stories/Article/Article/3955757/pentagon-says-10k-north-korean-troops-in-kursk-oblast/>.

6 U.S. Mission Korea, "Washington Declaration," press release, April 27, 2023, <https://kr.usembassy.gov/042723-washington-declaration/>.

7 Defense Intelligence Agency, *North Korea Military Power: A Growing Regional and Global Threat* (Washington, DC: Government Publishing Office, 2021), 6, <https://www.dia.mil/Portals/110/Documents/News/NKMP.pdf>.

Korea's nuclear weapons and missile programs. North Korea perceives South Korea and Japan as threats due to their alliances with the United States and their advancing military capabilities; it also perceives South Korea as an ideological threat due to its different political and economic systems. Further, North Korea generally sees the entire outside world as hostile due to a centuries-long history of invasion and subjugation. In particular, even though China has historically been an ally and partner to North Korea, North Korea still fears China's influence.

The DIA states North Korea has two main strategic objectives: to ensure North Korea remains a sovereign country ruled by the Kim family and to be capable of dominating the Korean Peninsula. Other references also include becoming a regional great power as a strategic objective.⁸ North Korea's strategy to achieve these objectives is to develop nuclear weapons and be recognized as a nuclear state, and it has taken concrete steps in the last few years to implement that strategy.⁹ In 2022, Kim Jong Un declared North Korea would never denuclearize, and North Korea adopted a new law that expanded the conditions under which North Korea would consider nuclear use to include a conventional attack (as opposed to only a nuclear attack) or if the regime's survival were threatened. In 2023–24, Kim called South Korea a hostile state that North Korea would subjugate if war broke out, a departure from traditional messaging.

THE CHALLENGE OF DETERRENCE

North Korea's history and current strategy and policy illustrate the difficulty of denuclearizing the Korean Peninsula and deterring North Korea. Negotiations have never been successful, and North Korea is more committed than ever to developing nuclear weapons. Furthermore, the risk of North Korean nuclear use exists whether or not North Korea is at an advantage, as long as it believes it can regain control in a crisis or conflict, or if the Kim regime is in imminent danger.

THE U.S.-ROK ALLIANCE

TNWs in South Korea would provide not only deterrence benefits but also assurance benefits. To understand how the TNWs would boost the credibility of the U.S. extended deterrence commitment to South Korea, it is critical to first understand the history and recent events of the U.S.-ROK alliance.

U.S.-ROK EXTENDED DETERRENCE

The U.S.-ROK alliance was established after the Korean War when the United States and South Korea signed the U.S.-ROK Mutual Defense Treaty, in which they pledged to “act to meet the common danger” if either party suffered an armed attack.¹⁰ U.S. President Dwight D. Eisenhower deployed TNWs to South Korea in 1958, although the primary purpose of the weapons was to deter the Soviet Union as part of Eisenhower's massive retaliation strategy.¹¹

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- 8 Bruce W. Bennett et al., “North Korea's National Strategy: Looking Beyond Nuclear Capability,” in *Countering the Risks of North Korean Nuclear Weapons* (Santa Monica, CA: RAND Corporation, 2021), 9, <https://www.rand.org/pubs/perspectives/PEA1015-1.html>.
 - 9 Mary E. Manyin and Mary Beth D. Nikitin, “U.S.-North Korea Relations,” Congressional Research Service, IF10246, December 6, 2024, <https://www.congress.gov/crs-product/IF10246>.
 - 10 “Mutual Defense Treaty Between the United States and the Republic of Korea; October 1, 1953,” in *American Foreign Policy 1950–1955* (Washington, DC: Government Publishing Office, 1957), https://www.usfk.mil/portals/105/documents/sofa/h_mutual%20defense%20treaty_1953.pdf.
 - 11 Yong-Sup Han, *South Korea and Nuclear Weapons: Retrospect and Prospects*, Policy Brief No. 56 (APLN/CNND, January 2018), 1, https://cms.apln.network/wp-content/uploads/2020/12/Policy-Brief-No-56-South-Korea-and-Nuclear-Weapons_Retrospect-and-Prospects.pdf.

In 1970, President Richard M. Nixon announced U.S. troops would be withdrawn from South Korea, and after the first troop withdrawal in 1972, South Korean President Park Chung Hee launched South Korea's nuclear weapons program. The United States soon discovered the program and pressured South Korea to end it and instead join the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) in 1975. South Korea ratified the NPT on the condition that the United States provide its nuclear umbrella to South Korea, and the United States promised to provide military assistance and stop withdrawing troops.

President Jimmy Carter tried to remove all troops from South Korea in 1977, saying the U.S. presence in South Korea was never meant to be permanent and South Korea was capable of defending itself.¹² However, many officials within the United States and among regional allies opposed this effort, and the United States ultimately made no changes to its forces in South Korea.

In 1991, to facilitate the negotiation of the Joint Declaration of South and North Korea on the Denuclearization of the Korean Peninsula, the United States removed all its TNWs from South Korea. Whatever the original intent, the U.S. decision to retain nuclear weapons in Europe but withdraw them from Asia has caused South Koreans to question the commitment of the United States to its Asian allies.¹³

RECENT EVENTS

After a short-lived maximum-pressure campaign with escalatory rhetoric, the first administration under President Donald Trump strove to negotiate with North Korea, offering concessions that affected the credibility of U.S. extended deterrence in South Korea.¹⁴ President Trump met with Kim Jong Un in Singapore, Hanoi, and the Demilitarized Zone in 2018–19.¹⁵ After the Singapore summit, President Trump suspended deployment of strategic assets to South Korea and suspended joint U.S.-ROK military exercises, apparently without consulting South Korea or U.S. forces.¹⁶ These deployments and joint exercises were key factors of U.S. assurance to South Korea. Despite these meetings and concessions, no progress was made toward denuclearization.

Following the first Trump administration, the Biden administration chose to prioritize strengthening extended deterrence in South Korea. Large-scale exercises resumed in 2022, although the long delay in resuming the exercises was due, at least in part, to the Covid-19 pandemic.¹⁷ However, due to increasing tensions with North Korea, President Yoon commented in January 2023 that South

12 Clint Work, "US Troops in Korea: From History's Vantage Point," 38 North, May 8, 2018, <https://www.38north.org/2018/05/cwork050818/>.

13 Peter K. Lee and Kang Chungku, *Comparing Allied Public Confidence in U.S. Extended Nuclear Deterrence* (Seoul: Asan Institute for Policy Studies, February 2024), https://asaninst.org/bbs/board.php?bo_table=s1_1_eng&wr_id=184&sfl=wr_subject%7C%7Cwr_content&stx=Comparing+Allied+Pub&sop=and.

14 Henry C. Jackson, "Trump Derides 'Little Rocket Man' in North Korea," *Politico*, September 22, 2017, <https://www.politico.com/story/2017/09/22/trump-little-rocket-man-north-korea-kim-jong-un-243045>; and Anthony Zurcher, "Donald Trump Threatens 'Fury' Against N Korea," BBC, August 8, 2017, <https://www.bbc.com/news/world-us-canada-40869319>.

15 Andrea Berger, "Trump-Kim Summit: Deciphering What Happened in Singapore," BBC, June 12, 2018, <https://www.bbc.com/news/world-asia-44451587>; Jung H. Pak, "The Good, the Bad, and the Ugly at the US-North Korea Summit in Hanoi," Brookings, March 4, 2019, <https://www.brookings.edu/articles/the-good-the-bad-and-the-ugly-at-the-us-north-korea-summit-in-hanoi/>; and James Doubek, "Trump Meets North Korea's Kim Jong Un and Says Nuclear Negotiations Will Resume," NPR, June 30, 2019, <https://www.npr.org/2019/06/30/737365074/trump-to-meet-kim-jong-un-at-dmz>.

16 Julian Borger, "US to Suspend Military Exercises with South Korea, Trump Says," *The Guardian*, June 12, 2018, <https://www.theguardian.com/us-news/2018/jun/12/us-to-suspend-war-games-with-south-korea-donald-trump-kim-jong-un-north-summit>.

17 Bruce Klinger, "U.S., South Korea to Resume Military Exercises," Heritage Foundation, August 22, 2022, <https://www.heritage.org/china/commentary/us-south-korea-resume-military-exercises>.

Korea would consider asking the United States to redeploy TNWs to South Korea or initiate its own nuclear weapons program if the North Korean threat continued to worsen.¹⁸ In April 2023, Biden and Yoon issued the Washington Declaration and established the NCG, which has increased U.S.-ROK collaboration on strategic planning, exercises, and communications, including the development of the U.S.-ROK Guidelines for Nuclear Deterrence and Nuclear Operations on the Korean Peninsula, announced in July 2024.¹⁹ After the Washington Declaration, the United States deployed strategic assets to South Korea over 30 times, including a strategic ballistic missile submarine (SSBN) for the first time since 1981.²⁰

As of April 2025, the second Trump administration's approach to deterrence and assurance on the Korean Peninsula remained to be seen. However, the United States and South Korea continue to collaborate on national security issues via several standing meetings, exercises, and groups, and the United States continues to provide support and training for both U.S. and ROK forces in South Korea via the joint command United States Forces Korea (USFK).

THE CHALLENGE OF EXTENDED DETERRENCE

Despite several current U.S.-ROK collaboration mechanisms, recent deployments, joint exercises, and the current U.S. commitment of forces to South Korea, the historically oscillatory nature of U.S. actions and rhetoric with respect to the U.S. security guarantee gives South Koreans cause for concern for their long-term future and reliance on the U.S. nuclear umbrella, especially given the growing North Korean threat and North Korea's ability to reach the U.S. mainland with ICBMs.

ARGUMENTS FOR DEPLOYING U.S. TNWS TO SOUTH KOREA

This section presents arguments for deploying U.S. TNWs to South Korea or establishing a nuclear-sharing agreement with South Korea. The two key benefits are improved deterrence of North Korea and improved assurance of South Korea. TNWs could also be used to further denuclearization and nonproliferation goals.

DETERRENCE OF NORTH KOREA

Ultimately, the decision to deploy U.S. TNWs to South Korea or establish a nuclear-sharing agreement would be part of the U.S.-ROK extended deterrence strategy, with the goal of deterring an attack on South Korea. Such a decision could also be part of a larger U.S. strategy to address the gap between U.S. TNWs and Russian and Chinese TNWs, but that problem set is beyond the scope of this work.

Hwee-rhak Park and Cheon Seong Whun state that the only two ways to restore the nuclear balance of power on the Korean Peninsula are redeploying U.S. TNWs to South Korea and South Korea acquiring its own nuclear weapons.²¹ They argue the only way to guarantee South Korea's security

18 Hyung-kyung Kang, "Yoon Keeps Possibility of Seoul's Possession of Nuclear Weapons Open," *Korea Times*, January 12, 2023, <https://www.koreatimes.co.kr/southkorea/politics/20230112/yoon-keeps-possibility-of-seouls-possession-of-nuclear-weapons-open>.

19 U.S. Mission Korea, "Joint Statement on U.S.-ROK Guidelines for Nuclear Deterrence and Nuclear Operations on the Korean Peninsula," press release, July 12, 2024, <https://kr.usembassy.gov/071224-joint-statement-by-president-biden-and-president-yoon-on-u-s-rok-guidelines-for-nuclear-deterrence-and-nuclear-operations-on-the-korean-peninsula/>.

20 Hyo-jin Lee, "US Extended Deterrence to Remain Strong Under Trump: Seoul Official," *Korea Times*, November 18, 2024, <https://www.koreatimes.co.kr/southkorea/defense/20241118/us-extended-deterrence-commitment-to-south-korea-expected-to-remain-strong-under-trump-seoul-official>; and Matt Murphy, "First US Nuclear Sub Docks in South Korea Since 1981," BBC, July 18, 2023, <https://www.bbc.com/news/world-asia-66233802>.

21 Cheon Seong Whun, "Redeploying American Tactical Nuclear Weapons to Counter North Korea's Nuclear Monopoly," Asan Institute for Policy Studies, December 17, 2018, https://asaninst.org/bbs/board.php?bo_table=s1_3_eng&wr_id=11&s-

against a nuclear threat is with a local nuclear deterrent. Whun points out an inconsistency in U.S. extended deterrence policy between Europe and Asia: The United States deploys TNWs to allies in Europe “with no overt nuclear threat” but relies only “on occasional displays of force to allay South Korea, which directly faces overt nuclear intimidation from North Korea.”²²

TNWs would also increase the credibility of deterrence in two ways. First, they would increase the credibility of the alliance. Duk-min Yun et al. write that the U.S.-ROK alliance itself is the “core deterrent” against North Korea, but the alliance has been losing credibility since the United States withdrew its nuclear weapons from South Korea in 1991.²³ Redeploying U.S. TNWs to South Korea or entering a nuclear-sharing agreement in the style of the North Atlantic Treaty Organization (NATO) would be one way to increase the credibility of the alliance to North Korea, although the authors state this option would be difficult for U.S.-ROK relations and for domestic political reasons (see the below section, “South Korean Public Backlash”).

The second way TNWs would increase credibility is that they would be more credible than strategic nuclear weapons. Park argues TNWs can be used more easily because they are less likely to be intercepted by an adversary’s ballistic missile defenses and could be used without the strategic consequences of strategic nuclear weapons. Because the barrier to U.S.-ROK use of TNWs would be lower, they would better deter North Korea.

Richard Sokolsky and Daekwon Son, however, disagree with the credibility arguments. Sokolsky says that U.S. extended deterrence is already sufficient to deter North Korea.²⁴ If the U.S. nuclear umbrella and USFK do not deter North Korea, then a few more weapons in South Korea will not change that calculus. Son additionally explains that a threat to use conventional weapons is more credible than a threat to use nuclear weapons because conventional attacks are not subject to the nuclear taboo and they do not cause as much collateral damage as nuclear weapons.²⁵

Finally, Sokolsky gives another counterargument for deterrence: TNWs in South Korea could decrease first-strike stability on the peninsula because the short distances from South Korea to North Korea would compress decisionmaking time.²⁶ Both sides’ nuclear weapons would be vulnerable to a preemptive first strike, which is a strong incentive to use nuclear weapons first. However, this may be less of an issue if North Korea develops a secure second-strike capability, such as its own nuclear submarine force.²⁷

ASSURANCE OF SOUTH KOREA

Given South Korea’s concerns about the U.S.-ROK alliance, one of the most-cited motivations for redeploying U.S. TNWs to South Korea or establishing a nuclear-sharing agreement is to improve the

fl=wr_subject%7C%7Cwr_content&stx=U.S.+Global&sop=and&page=2; and Hwee-rhak Park, *The Desirability and Feasibility of Nuclear Sharing in Northeast Asia: A South Korean Perspective* (Seoul: East Asia Institute, 2017), https://www.eai.or.kr/eng/project/project_01_view.php?no=11100&project=137.

22 Whun, “Redeploying American Tactical Nuclear Weapons.”

23 Duk-min Yun et al., “Recommendations for Stronger US-ROK Alliance to Respond to North Korea’s Growing Nuclear Threat,” CSIS, January 2021, <https://www.csis.org/analysis/guest-contribution-make-us-rok-alliance-stronger-respond-north-koreas-growing-nuclear>.

24 Richard Sokolsky, “The Folly of Deploying US Tactical Nuclear Weapons to South Korea,” 38 North, December 1, 2017, <https://www.38north.org/2017/12/rsokolsky120117/>.

25 Daekwon Son, “Flawed Assumption in Pro-Nuclear Arguments and South Korea’s Strategic Choice,” *Asian Perspective* 43, no. 1 (2019): 123–44, <https://doi.org/10.1353/apr.2019.0004>.

26 Sokolsky, “The Folly of Deploying.”

27 Anubhav Shankar Goswami, “North Korea’s Growing SSBN Capabilities: Strategic Implications,” Observer Research Foundation, April 15, 2025, <https://www.orfonline.org/expert-speak/north-korea-s-growing-ssbn-capabilities-strategic-implications>.

credibility of U.S. nuclear assurance to South Korea. Jordan E. Murphy cites a 2007 Simons Foundation study that shows nuclear sharing improves assurance but emphasizes South Korea must request nuclear sharing from the United States; if the United States imposes its nuclear weapons on South Korea against its will, then the United States could actually further deteriorate assurance.²⁸

However, multiple articles against TNWs in South Korea claim disagreements about authorities and responsibilities could actually worsen the U.S.-ROK relationship. Sokolsky, Joshua Byun and Do Young Lee, Lauren Sukin, and Eric Heginbotham and Richard J. Samuels all point out that deciding who has what authorities and responsibilities for the TNWs could cause disagreements between the United States and South Korea.²⁹ Within NATO's nuclear sharing, "the United States maintains absolute control and custody of its nuclear weapons forward-deployed in Europe, while Allies provide military support for the DCA mission with conventional forces and capabilities."³⁰ No NATO ally can decide to use a nuclear weapon without the approval of the U.S. president. This type of sharing may not provide South Korea the assurance it needs; South Korea may want more authority over the weapons, which could cause friction in the alliance.

DENUCLEARIZATION OF NORTH KOREA

U.S. redeployment of TNWs to South Korea or a nuclear-sharing agreement could affect any strategy to pursue denuclearization of North Korea. Park, Murphy, and Amy F. Woolf and Emma Chanlett-Avery argue the United States and ROK could use the deployed TNWs as a bargaining chip to get North Korea to denuclearize.³¹ Murphy says this strategy is analogous to the Pershing II missiles bringing Soviet leaders to the table to sign the Intermediate-Range Nuclear Forces Treaty in 1987.³² Sokolsky and Woolf and Chanlett-Avery additionally argue TNWs could pressure China to, in turn, pressure North Korea to denuclearize.³³

However, Park, Sokolsky, and Woolf and Chanlett-Avery caution that nuclear weapons in South Korea could legitimize North Korean nuclear weapons: Deploying TNWs to South Korea would undercut South Korea's moral authority and make the demand for North Korean denuclearization less persuasive.³⁴

NONPROLIFERATION

U.S. redeployment of TNWs to South Korea or a nuclear-sharing agreement could decrease the probability of South Korea developing its own nuclear weapons. Park, Whun, and Yun et al. argue the United States must deploy TNWs to South Korea or South Korea must develop its own nuclear

28 Jordan E. Murphy, *Assuring the Republic of Korea Through Nuclear Sharing: A Blueprint for an Asian Ally* (Montgomery, AL: Air War College, May 2019), 13, https://au.primo.exlibrisgroup.com/discovery/delivery/01AUL_INST:AUL/1281122480006836.

29 Sokolsky, "The Folly of Deploying"; Joshua Byun and Do Young Lee, "The Case Against Nuclear Sharing in East Asia," *Washington Quarterly* 44, no. 4 (2021): 67–87, <https://doi.org/10.1080/0163660X.2021.2018793>; Lauren Sukin, "The US Has a New Nuclear Proliferation Problem: South Korea," *Bulletin of the Atomic Scientists*, January 19, 2023, <https://thebulletin.org/2023/01/the-us-has-a-new-nuclear-proliferation-problem-south-korea/>; and Eric Heginbotham and Richard J. Samuels, "Vulnerable US Alliances in Northeast Asia: The Nuclear Implications," *Washington Quarterly* 44, no. 1 (2021), 157–75, <https://doi.org/10.1080/0163660X.2021.1894709>.

30 "NATO's nuclear deterrence policy and forces," NATO, June 24, 2025, <https://www.nato.int/en/what-we-do/deterrence-and-defence/natos-nuclear-deterrence-policy-and-forces?selectedLocale=>.

31 Park, *The Desirability and Feasibility of Nuclear Sharing*; and Amy F. Woolf and Emma Chanlett-Avery, *Redeploying U.S. Nuclear Weapons to South Korea: Background and Implications in Brief*, CRS Report No. R44950 (Washington, DC: Congressional Research Service, September 14, 2017), https://www.congress.gov/crs_external_products/R/PDF/R44950/R44950.3.pdf.

32 Murphy, *Assuring the Republic of Korea*.

33 Sokolsky, "The Folly of Deploying"; and Woolf and Chanlett-Avery, *Redeploying U.S. Nuclear Weapons*.

34 Park, *The Desirability and Feasibility of Nuclear Sharing*; Sokolsky, "The Folly of Deploying"; and Woolf and Chanlett-Avery, *Redeploying U.S. Nuclear Weapons*.

weapons to face the North Korean nuclear threat.³⁵ U.S. TNWs are likely the better option for both the United States and South Korea due to the costs of leaving the NPT. Although this argument is something of a false dichotomy—no articles definitively prove other options will not work, such as strengthening conventional capabilities or improving the existing extended deterrence framework—if this mindset becomes more popular in South Korea, then the probability of South Korea developing its own nuclear weapons could increase if the United States chooses not to deploy TNWs to South Korea or enter a nuclear-sharing agreement. Murphy also cites a study by Dan Reiter that finds that, historically, deployed nuclear weapons generally decrease the probability a country will seek to develop its own nuclear weapons more than alliances and deployed troops.³⁶

Conversely, Yun et al. and Sukin provide alternatives to TNWs for preventing proliferation in South Korea.³⁷ If South Korea seems to be on the brink of establishing its own nuclear weapons program, the United States, instead of resorting to TNWs, could emphasize to South Korea how its reputation would be damaged and prioritize restraint and arms control efforts. The United States could also encourage South Korea to take actions to “leave its nuclear options open” but stop short of initiating a program.³⁸

ARGUMENTS AGAINST DEPLOYING U.S. TNWS TO SOUTH KOREA

This section presents arguments against deploying U.S. TNWs to South Korea or establishing a nuclear-sharing agreement with South Korea. The two key arguments are that (1) the operational utility of the TNWs would be minimal and (2) North Korea, China, the South Korean public, and Japan could all react unfavorably. A discussion of implementation costs is critical to this debate but outside the scope of this paper; see references by David P. Phillips and Murphy for more information on that topic.³⁹

OPERATIONAL CONSIDERATIONS

Regardless of deterrence effects, most articles against TNWs in South Korea claim that existing capabilities are sufficient to defeat North Korea and that TNWs would not offer any operational advantage. Sokolsky claims that U.S. “conventional and nuclear weapons can cover any targets that need to be destroyed in North Korea.”⁴⁰ Heginbotham and Samuels similarly state that because the United States can already launch weapons from aircraft and ships, TNWs in South Korea are unnecessary.⁴¹

Son explores South Korea’s conventional advantage in detail to show that South Korea’s conventional superiority is sufficient to defeat North Korea. During the Cold War, the only way to inflict unacceptable damage was with nuclear weapons, but Son cites studies that show conventional weapons can now achieve many of the same operational outcomes nuclear weapons can, as demonstrated during the Gulf War.⁴² Modern conventional capabilities include, for example, precision-

35 Hwee-rhak Park, “Investigating Nuclear-Armed North Korea’s ‘Strategic’ Challenge and Options for the United States and South Korea,” *International Area Studies Review* 25, no. 3 (2022): 177–94, <https://doi.org/10.1177/22338659221112990>; Park, *The Desirability and Feasibility of Nuclear Sharing*; Whun, “Redeploying American Tactical Nuclear Weapons”; and Yun et al., *Recommendations for Stronger US-ROK Alliance*.

36 Dan Reiter, “Security Commitments and Nuclear Proliferation,” *Foreign Policy Analysis* 10, no. 1 (2014): 61–80, <https://www.jstor.org/stable/24910787>.

37 Yun et al., *Recommendations for Stronger US-ROK Alliance*; and Sukin, “The US Has a New Nuclear Proliferation Problem.”

38 Yun et al., *Recommendations for Stronger US-ROK Alliance*, 3.

39 Murphy, *Assuring the Republic of Korea*; and David P. Phillips, “Nuclear Redeployment: A Roadmap for Returning Nonstrategic Nuclear Weapons to the Korean Peninsula,” in *On the Horizon: A Collection of Papers from the Next Generation*, vol. 7, ed. Doreen Horschig (Washington, DC: CSIS, 2024), 12–38, <https://www.csis.org/analysis/horizon-vol-7>.

40 Sokolsky, “The Folly of Deploying.”

41 Heginbotham and Samuels, “Vulnerable U.S. Alliances.”

42 Son, “Flawed Assumption.”

guided munitions that can target mobile nuclear weapons and weapons that can target hard and deeply buried targets (although some sources say nuclear weapons are still required to hold very deeply buried targets at risk).⁴³

As a counterargument, Park offers one operational example where TNWs could be useful: If North Korea launched a surprise ground invasion, then South Korea and the United States could “destroy the main body and reserves of the North Korean surprise attack with a few tactical nuclear weapons.”⁴⁴

A final operational consideration from Woolf and Chanlett-Avery is that redeploying U.S. TNWs to South Korea could drain funds from other military priorities, so some other capability may have to be sacrificed to pursue this option.⁴⁵

NORTH KOREAN REACTION

Even if redeployment of TNWs to South Korea or a nuclear-sharing agreement improves nuclear deterrence, those actions could still alarm North Korea and trigger an unfavorable reaction. Sokolsky predicts North Korea will respond by accelerating its nuclear weapons development, which could trigger an arms race on the peninsula.⁴⁶ Murphy also acknowledges this possibility but says an arms race is unlikely because the United States and South Korea will not need many nuclear weapons for an effective deterrent and will not try to outnumber North Korea.⁴⁷ Murphy predicts North Korea will respond either similarly to how it responded to U.S.-ROK joint exercises—with nuclear and missile tests—or with an escalation of rhetoric or threats. Murphy believes the risk of North Korean military action is acceptably low. But, according to Woolf and Chanlett-Avery, even if North Korea does not respond with military action, escalatory rhetoric, missile tests, or developments in its nuclear weapons program could further unnerve the South Korean public, making them feel less secure.⁴⁸

Proponents, however, believe the risk of an unfavorable reaction from North Korea could be mitigated. Park believes the risk could be mitigated by taking action only in response to something North Korea does first.⁴⁹ But, given the timeline of redeploying TNWs to South Korea or establishing a nuclear-sharing agreement, aligning the deployment schedule with North Korean provocation may be difficult and would require substantial planning. Phillips proposes several risk mitigation measures, including building consensus among allies and stakeholders in the region and executing an information campaign to explain that TNWs in South Korea are a moderate response to the growing North Korean nuclear threat.⁵⁰ Sokolsky also specifies several messages the United States could communicate to North Korea:

1. The United States is not threatening regime change or nuclear attack.
2. The United States would use nuclear weapons only in response to a North Korean attack.

43 U.S. Department of Defense, “Fact Sheet on B61 Variant Development,” press release, October 27, 2023, <https://media.defense.gov/2023/Oct/27/2003329624/-1/-1/1/B61-13-FACT-SHEET.PDF>; and Michaela Dodge, “Out of Sight Should Not Mean Out of Reach: Deterrence and the Proliferation of Hard and Deeply Buried Targets,” RealClear Defense, June 11, 2021, https://www.realcleardefense.com/articles/2021/06/11/out_of_sight_should_not_mean_out_of_reach_deterrence_and_the_proliferation_of_hard_and_deeply_buried_targets_780952.html.

44 Park, *The Desirability and Feasibility of Nuclear Sharing*, 19.

45 Woolf and Chanlett-Avery, *Redeploying U.S. Nuclear Weapons*.

46 Sokolsky, “The Folly of Deploying.”

47 Murphy, *Assuring the Republic of Korea*.

48 Woolf and Chanlett-Avery, *Redeploying U.S. Nuclear Weapons*.

49 Park, “Investigating Nuclear-Armed North Korea’s ‘Strategic’ Challenge.”

50 Phillips, “Nuclear Redeployment.”

3. The United States is prepared to negotiate.
4. The United States is prepared to withdraw the weapons in exchange for progress toward denuclearization.⁵¹

CHINA'S REACTION

North Korea's reaction is not South Korea's only concern. South Korea must also manage its relationship with China. According to Hans M. Kristensen and Robert S. Norris, Woolf and Chanlett-Avery, and Park, China may see the deployment of U.S. TNWs to South Korea or a nuclear-sharing agreement as escalatory and respond in a variety of ways:⁵²

- China might accelerate its own nuclear weapons development or even increase support for North Korea, possibly starting an arms race in northeast Asia.
- China (and Russia) may see this action as providing the United States a regional nuclear strike option below the strategic level and change its strategies and deployments to similarly undermine the security of South Korea and Japan.
- More generally, China could react in a way that disrupts U.S. interests in the region.

As discussed, Park believes the risk of an escalatory response from China (or Russia or North Korea) could be mitigated by pursuing deployment of TNWs step-by-step, taking the next step only after tensions rise.⁵³ But again, given the timeline of redeploying TNWs to South Korea, aligning the deployment schedule with North Korean provocation may be difficult and would require substantial thought and planning. Phillips proposes planning to provide economic aid to South Korea to anticipate China's potential economic retaliatory measures.⁵⁴

SOUTH KOREAN PUBLIC BACKLASH

South Korea must worry not only about its adversaries' reactions but also about public opinion. Not all South Koreans want U.S. TNWs in South Korea, and a South Korean administration that decides to bring U.S. TNWs to South Korea may suffer public backlash. Sukin uses survey data to understand public thinking about this issue.⁵⁵ If South Koreans really did not have faith in U.S. extended deterrence and wanted the United States to demonstrate its commitment by redeploying TNWs to South Korea, then faith in the U.S. deterrent should be *negatively* correlated with the desire for South Korea to build its own nuclear weapons. However, survey data show that among the South Korean public, faith in the U.S. extended deterrent is *positively* correlated with the desire for South Korea to build its own nuclear capabilities.

Sukin explains that South Koreans do not trust the United States to be cautious or responsibly manage escalation.⁵⁶ The United States would not suffer the environmental and health effects South Koreans would suffer in the event of a nuclear exchange on the peninsula. Moreover, the United States has an incentive to use nuclear weapons to eliminate North Korean weapons that can reach the U.S. mainland and may even drag South Korea into a war it would not have fought otherwise.

51 Sokolsky and 38 North, "The Folly of Deploying."

52 Hans M. Kristensen and Robert S. Norris, "A History of US Nuclear Weapons in South Korea," *Bulletin of the Atomic Scientists* 73, no. 6 (2017): 349–57, <https://doi.org/10.1080/00963402.2017.1388656>; Woolf and Chanlett-Avery, *Redeploying U.S. Nuclear Weapons*; and Park, "Investigating Nuclear-Armed North Korea's 'Strategic' Challenge."

53 Park, "Investigating Nuclear-Armed North Korea's 'Strategic' Challenge."

54 Phillips, "Nuclear Redeployment."

55 Sukin, "The US Has a New Nuclear Proliferation Problem."

56 Ibid.

Sukin additionally says public survey data show two-thirds of South Koreans prefer that South Korea develop its own nuclear weapons over hosting U.S. TNWs, whereas less than 10 percent prefer U.S. TNWs over South Korean nuclear weapons. Moreover, 40 percent of South Koreans opposed U.S. TNWs, whereas only 26 percent opposed South Korean nuclear weapons.

Conversely, Whun does not believe public backlash would be an issue if the South Korean government communicates the North Korean threat to the public, builds public trust in U.S. extended nuclear deterrence, and openly demands the United States redeploy TNWs to South Korea.⁵⁷

JAPAN'S REACTION

Finally, South Korea would need to consider Japan's reaction. Given Japan's unique status of being the only country to have suffered nuclear attacks, Japan may oppose TNWs in South Korea and may fear getting caught up in a northeast Asia arms race, according to Woolf and Chanlett-Avery and Park.⁵⁸

However, Park and Byun and Lee suggest Japan join a NATO-style nuclear-sharing agreement with allies in the Indo-Pacific region to improve assurance in both Japan and South Korea.⁵⁹

FINDINGS

This section discusses the differences between arguments for and against U.S. TNWs in South Korea. It also suggests further research that could resolve—or at least shrink—the differences and highlights inherent risks and possible mitigations.

- **The effect of U.S. TNWs in South Korea on deterring North Korea is uncertain and should be a priority for further study.** Some articles claim nuclear weapons in South Korea are the only way to deter a nuclear North Korea, whereas others claim they either would have no impact on deterrence or are unnecessary. Few support the operational advantage offered by TNWs in South Korea, except for the ability to target deeply buried targets. An exploration of the connection between the operational impact that TNWs in South Korea would have on a conflict and North Korea's decision calculus could elucidate deterrence benefits. This exploration could be done via tabletop exercises or other simulations with both U.S. and South Korean participants to inform whether those benefits are worth the costs.
- **The United States and South Korea would have to agree on the division of responsibilities and authorities to ensure U.S. TNWs successfully assure South Korea.** Before deciding to pursue a nuclear-sharing agreement, the United States and South Korea would first need to discuss and agree on the division of authorities and responsibilities, and determine whether that division achieves assurance goals. This consideration is especially important because TNWs in South Korea would not necessarily address one of the root causes of South Korea's concerns: the fact that North Korean ICBMs can reach the U.S. mainland. South Korea would likely be interested in exploring how different nuclear-sharing options would affect strategic deterrence of North Korea and how the weapons would be employed in a conflict. This could potentially be studied simultaneously with the tabletop exercises and simulations proposed in the previous paragraph.
- **The effect of U.S. TNWs in South Korea on denuclearization efforts is uncertain but may not be a priority for further study.** While most agree that U.S. TNWs in South Korea would likely decrease

57 Whun, "Redeploying American Tactical Nuclear Weapons."

58 Woolf and Chanlett-Avery, *Redeploying U.S. Nuclear Weapons*; and Park, *The Desirability and Feasibility of Nuclear Sharing*.

59 Park, *The Desirability and Feasibility of Nuclear Sharing*; and Byun and Lee, "The Case."

the probability of South Korean nuclearization, the effect on North Korean denuclearization efforts is uncertain. Further study on how North Korea might react to the bargaining chip strategy may be interesting, but the precedent set by the U.S. withdrawing its TNWs in 1991 suggests such a strategy would be extremely difficult to implement. The relevance of this consideration also depends on whether the United States and South Korea choose to continue to pursue the goal of complete denuclearization of the peninsula. The United States and South Korea recently agreed to use the expression “denuclearization of North Korea” rather than “denuclearization of the Korean Peninsula.” Although the primary purpose of the change was likely to nullify North Korea’s claim that the U.S. nuclear umbrella counts as nuclearization of South Korea, the expression also no longer rules out the possibility of U.S. TNWs in South Korea or even South Korea initiating its own nuclear program.⁶⁰

- **The United States and South Korea would have to plan how they will mitigate potential negative reactions from North Korea and China.** Most articles, for or against, acknowledge the risk of negative reactions from North Korea and China; the point of disagreement is how well potential negative reactions could be mitigated. The United States and South Korea could conduct a risk assessment of possible reactions to a variety of implementation plans and identify mitigation options to inform leaders about the potential costs of their decision and how to minimize them.
- **The South Korean administration would need to consider its constituents’ opinions.** For example, a South Korean administration would want to understand whether U.S. TNWs in South Korea would reassure the public or heighten their concerns. This could be determined via polls or surveys.
- **The United States and South Korea should collaborate with Japan.** Finally, Japan is also a key stakeholder and ally in the region. The United States and South Korea should communicate with Japan to understand its perspective—and, ideally, collaborate—on deploying TNWs in South Korea if leaders decide to pursue this option.

CONCLUSION

North Korea continues to develop its nuclear weapons program despite decades of effort by the international community to end the program. South Korea relies strongly on the U.S. nuclear umbrella to deter North Korea, but North Korea’s weapons advancements and U.S. rhetoric and actions make South Korea question the U.S. assurance commitment.

Redeploying U.S. TNWs to, or entering a nuclear-sharing agreement with, South Korea may improve deterrence and assurance on the peninsula, but this decision would be expensive and time-consuming to implement.

The strategic deterrence and operational benefits of TNWs in South Korea are uncertain and warrant further study, perhaps via tabletop exercises or other simulations. Both sides would also need to carefully discuss and understand assurance benefits before any decision is made. The decision carries risks of unfavorable reactions from North Korea and China, and the spectrum of potential consequences, their probabilities, and possible mitigations should be determined systematically for decisionmakers. A South Korean administration would have to consider the opinions of its

60 Sang-ho Song, “S. Korea, U.S. Agree to Use Expression, ‘Denuclearization of N. Korea; Not ‘of Korean Peninsula’: Seoul Envoy,” Yonhap News Agency, February 27, 2025, <https://m-en.yna.co.kr/view/AEN20250227000200315?section=nk/nk>; and Jeongmin Kim, “US, ROK Agree to Push for ‘Denuclearization of North Korea; Not of ‘Peninsula,’” NK News, February 28, 2025, <https://www.nknews.org/2025/02/us-rok-agree-to-push-for-denuclearization-of-north-korea-not-of-peninsula/>.

constituents and the potential political costs, and Japan is a key stakeholder and ally in the region that, ideally, would be involved in this discussion.

Given the costs and risks, alternative solutions may be worthy of further study before, or in conjunction with, pursuing these options. Bruce W. Bennett et al., Heginbotham and Samuels, Sokolsky, and Yun et al. all propose improving U.S.-ROK collaboration mechanisms.⁶¹ Additionally, Bennett et al. suggest implementing more measures to slow North Korea's nuclear weapons development. Sokolsky suggests deploying SSBNs or dual-capable aircraft to South Korea more frequently, and Heginbotham and Samuels suggest exploring the concept of sharing nuclear weapons with South Korea only during wartime.

61 Bruce W. Bennett et al., *Options for Strengthening ROK Nuclear Assurance* (Santa Monica, CA: RAND Corporation, 2023), https://www.rand.org/pubs/research_reports/RRA2612-1.html; Heginbotham and Samuels, "Vulnerable"; Sokolsky, "The Folly of Deploying"; and Yun et al., *Recommendations for Stronger US-ROK Alliance*.

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