



Technology Acquisition and Arms Control: Thinking Through the Hypersonic Weapons Debate

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Debates in the United States about hypersonic weapons today revolve around acquiring hypersonic missiles and pursuing arms control initiatives, but concern about a hypersonic gap is misplaced and indicates a misunderstanding about the strategic trade-offs and benefits associated with hypersonic technology. Similarly, arms control solutions proposed to date have not paid enough attention to the specifics of the weapons and their implications for strategic stability. Using hypersonic weapons as a case study, I outline a theoretical framework for making decisions about acquiring new technology and developing arms control proposals. Ultimately, I conclude that U.S. policy on the acquisition of hypersonic missile technology overstates the immediate need for these missiles, falls short on offering strategies that would discourage adversaries from developing such weapons, and under-emphasizes the importance of nonproliferation efforts.

In October 2021, reports surfaced that China had tested two hypersonic missiles capable of evading American missile defenses and early warning detection, catching the world — including the United States — off guard. The tests, which involved launching a potentially nuclear-armed hypersonic missile into orbit that then circled the globe and reentered the atmosphere through the use of a second rocket, prompted Chairman of the Joint Chiefs of Staff Gen. Mark Milley to call it a “near Sputnik moment” in congressional testimony.¹ The revelations prompted U.S. lawmakers to call for increased spending on hypersonic capabilities — which America has not yet mastered — as they expressed concern that the United States was falling behind in this newest arms race.²

Leaving aside that China’s orbital approach was not in fact new, but a variation of a 1960s-era Soviet strategy known as a Fractional Orbital Bombardment System, concern about the United States falling behind on hypersonic capabilities is misplaced. Indeed, the panic over technological parity misunderstands the trade-offs and benefits associated with hypersonic weapons investment and technology. Hypersonic weapons technology is both expensive to obtain and provides few benefits

to already dominant powers. By contrast, the proliferation of such technology may significantly reduce strategy stability and increase the probability of general war as it increases the speed of decision-making associated with nuclear defense. In a resource-constrained world, policy choices about weapons acquisition are some of the most costly decisions that a state can make. They require a theoretical framework that allows a state to invest wisely in the technology that will define the future.

Policymakers today are grappling with two big questions — questions that might be asked of any new technology. First, should the United States aggressively pursue the acquisition of hypersonic weapons? And second, should America attempt to limit the proliferation of hypersonic weapons through arms control measures? These questions, while related, are in fact analytically distinct and should be treated as such. This paper develops a framework, derived from the theoretical literature, for thinking through these policy questions, and it offers a first cut at how the field might think through the introduction of hypersonic missiles. Its primary contribution, therefore, is to outline what the theoretical literature has to say about the acquisition of new technology and the utility of arms

1 Sara Sorcher and Karoun Demirjian, “Top U.S. General Calls China’s Hypersonic Weapon Test Very Close to a ‘Sputnik Moment,’” *Washington Post*, Oct 27, 2021, <https://www.washingtonpost.com/nation/2021/10/27/mark-milley-china-hypersonic-weapon-sputnik/>.

2 Jordan Williams, “Gaetz, Austin Spar Over Wokeism, Hypersonic Competition and ‘Blown Calls’ by the Pentagon,” *The Hill*, April 5, 2022, <https://thehill.com/policy/defense/3259507-gaetz-austin-spar-over-wokeism-hypersonic-competition-and-blown-calls-by-the-pentagon/>.



control, using hypersonic weapons as a case study. Ultimately, I conclude that current U.S. policy toward hypersonic weapons acquisition overstates the immediate need for these missiles, falls short on providing alternative methods for discouraging their development, and under-emphasizes the importance of nonproliferation efforts.

The Hypersonic Debate

Hypersonic weapons are maneuverable missiles that can travel through the Earth's atmosphere at speeds five times or more above the speed of sound. They are distinct from other types of missiles because of the unique combination of speed and maneuverability. While ballistic missiles often travel at speeds of more than 20 times the speed of sound and can cover the span of the globe, they leave the Earth's atmosphere and follow a predictable ballistic trajectory. As a result, their targets are easily identifiable and, in some cases, defensible. By contrast, cruise missiles travel closer to the ground and are maneuverable, but move relatively slowly at short ranges, making their targets more defensible and the missiles identifiable. Hypersonic weapons, however, are both very fast and maneuverable within the Earth's atmosphere across long distances, generating particular problems for both target identification and defense.³

The advent of this new technology — a breakthrough in both aerodynamic propulsion and material science — has led to considerable concern among U.S. policymakers that the United States is falling behind in ways that will jeopardize its ability to compete with near-peer adversaries going forward.⁴ Hypersonic weapons are regularly compared to other so-called revolutionary technologies

such as nuclear weapons and artificial intelligence,⁵ even as the academic community remains undecided about the potential implications of hypersonic technology for both warfighting outcomes and the international system. While the more bullish literature has focused on the technical benefits of the weapons for achieving strategic goals,⁶ recent scholarship has been decidedly less sanguine about their effects on the international system and has raised varying degrees of concern about the implications of hypersonic missiles for everything from strategic stability to alliance assurance to inadvertent escalation.⁷ Implicit in these arguments is a warning: Acquiring hypersonic capabilities may do more harm to international security than good.

Relatedly, other scholars have seen hypersonic weapons as a source of concern because they could spark a new arms race and have ushered in a new round of calls for arms control and nonproliferation agendas. Some focus on preventing the spread of the technology itself beyond the top three indigenous programs (the United States, Russia, and China),⁸ while others focus on limiting the use and deployment of hypersonic weapons once they have been introduced into a state's arsenal.⁹ Others still point to the demise of existing arms control efforts such as the Anti-Ballistic Missile Treaty as responsible for the current race and advocate for a return to such agreements that would leave all states vulnerable to attack.¹⁰

These efforts, however, miss a critical step in the design of policy solutions: They have yet to determine exactly what problems hypersonic weapons pose to global strategic stability. Rather, they appear to rely upon assumptions that either the spread of the technology is fundamentally destabilizing and therefore nonproliferation must be a priority,¹¹ or that any kind of arms control agreement

3 For an overview of hypersonic weapons and their characteristics, see James M. Acton, *Silver Bullet? Asking the Right Questions About Conventional Prompt Global Strike*, Carnegie Endowment for International Peace, 2013, <https://carnegieendowment.org/files/cpgs.pdf>; and Richard H. Speier, et al., *Hypersonic Missile Nonproliferation: Hindering the Spread of a New Class of Weapons* (Santa Monica, CA: RAND Corporation, 2017).

4 Shannon Bugos, "Congress Authorizes Accelerated Hypersonics Plan," *Arms Control Today* (January/February 2022), <https://www.armscontrol.org/act/2022-01/news/congress-authorizes-accelerated-hypersonics-plan-0>.

5 "Breaking New Barriers: The Rise of Hypersonics," Deloitte, accessed Aug. 29, 2022, <https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/rise-of-hypersonics.html>; and Nathan B. Terry and Paige Price Cone, "Hypersonic Technology: An Evolution in Nuclear Weapons?" *Strategic Studies Quarterly* 14, no. 2 (Summer 2020): 74–99, <https://www.jstor.org/stable/26915278>.

6 Alan Cummings, "Hypersonic Weapons: Tactical Uses and Strategic Goals," *War on the Rocks*, Nov. 12, 2019, <https://warontherocks.com/2019/11/hypersonic-weapons-tactical-uses-and-strategic-goals/>.

7 Dean Wilkening, "Hypersonic Weapons and Strategic Stability," *Survival* 61, no. 5 (2019): 129–48, <https://doi.org/10.1080/00396338.2019.1662125>; Rupal N. Mehta, "Extended Deterrence and Assurance in an Emerging Technology Environment," *Journal of Strategic Studies* 44, no. 7 (2021): 958–82, <https://doi.org/10.1080/01402390.2019.1621173>; Caitlin Talmadge, "Emerging Technology and Intra-war Escalation Risks: Evidence from the Cold War, Implications for Today," *Journal of Strategic Studies* 42, no. 6 (2019): 864–87, <https://doi.org/10.1080/01402390.2019.1631811>.

8 Speier et al., *Hypersonic Missile Nonproliferation*.

9 Heather Williams, "Asymmetric Arms Control and Strategic Stability: Scenarios for Limiting Hypersonic Glide Vehicles," *Journal of Strategic Studies* 42, no. 6 (2019): 789–813, <https://doi.org/10.1080/01402390.2019.1627521>.

10 Sanne Verschuren, "China's Hypersonic Weapons Test Don't Have to Be a Sputnik Moment," *War on the Rocks*, Oct. 29, 2021, <https://warontherocks.com/2021/10/chinas-hypersonic-missile-tests-dont-have-to-be-a-sputnik-moment/>.

11 Speier et al., *Hypersonic Missile Nonproliferation*.

will be a step toward solving destabilizing properties associated with hypersonic glide vehicles.¹² Indeed, little systematic analysis has been conducted to identify which of the several changes hypersonic weapons introduce into nuclear and conventional deterrence poses the greatest risks. Perhaps more troubling, there has been no effort to examine whether certain aspects of hypersonic weapons may, in fact, be stabilizing.¹³ As a result, arms control analysis risks developing solutions for the wrong problems, or even developing solutions that risk further destabilization.

We are, therefore, in need of a framework that policymakers and scholars alike might use to advance the discussion about hypersonic weapons development, and about new technologies more generally. The remainder of this paper walks through the theoretical considerations that inform decisions about weapons acquisition and arms control and examines how hypersonic weapons might be evaluated under such a framework. It concludes with a discussion of current U.S. policy and publicly available acquisition and arms control efforts, evaluating both their efficacy and likelihood of success.

Acquiring Technology: Theoretical Considerations and Applications to Hypersonic Weapons

Each new advancement in weapons technology, in theory, fills a new need or offers new capabilities that previous weapons systems did not offer or allow. Nuclear weapons offered the destructive potential of thousands of bombs in a single warhead, precision-guided munitions allowed for the ability to hit a single facility with a single warhead with confidence, and artificial intelligence promises to accelerate the speed of war while minimizing

the cost in human lives. Each of these technologies offers substantial improvements upon previous systems and methods, providing leaders and decision-makers greater flexibility and more capabilities than before.

While the United States has devoted significant amounts of funding and attention to the development of hypersonic technology, there is still a robust debate about how aggressively the military should pursue acquiring such weapons for widespread use.¹⁴ New technologies are expensive and require modernization efforts and retrofitting initiatives that can be costly in terms of both financial and human capital. Similarly, possessing the technical know-how is different from actually acquiring and integrating the new capability, as is the case with many nuclear weapons states. Decisions about new technological acquisitions, therefore, should take into account two factors: warfighting costs and benefits and strategic effects.

Warfighting Effects

Technology can, at times, increase a state's warfighting potential and therefore provide advantages on the battlefield that make investing in such technologies necessary for success in war. In general, new technologies may contribute to warfighting in two ways. First, they can increase the probability that a state will win a war. Technologies that overwhelm existing defenses or enable new strategies can change the balance of power on the battlefield and increase the likelihood that states will be victorious.¹⁵ They may also decrease the costs associated with particular strategies, allowing states to conduct operations for longer and with more vigor, leading to significant advantages on the battlefield.¹⁶ New technology may also change the balance of power by making one side more lethal and

12 Williams, "Asymmetric Arms Control and Strategic Stability."

13 Keir A. Lieber and Daryl G. Press, "The New Era of Counterforce: Technological Change and the Future of Nuclear Deterrence," *International Security* 41, no. 4 (Spring 2017): 9–49, https://doi.org/10.1162/ISEC_a_00273.

14 Ryan Hilger, "Red Sky in Morning: Naval Combat at the Dawn of Hypersonics," *War on the Rocks*, Feb. 28, 2019, <https://warontherocks.com/2019/02/red-sky-in-morning-naval-combat-at-the-dawn-of-hypersonics/>; Paul McLeary, "PACOM Harris: U.S. Needs to Develop Hypersonic Weapons, Criticizes 'Self-Limiting' Missile Treaties," *UNSI News*, Feb. 14, 2018, <https://news.usni.org/2018/02/14/pacom-harris-u-s-needs-develop-hypersonic-weapons-criticizes-self-limiting-missile-treaties/>; Heather Venable and Clarence Abercrombie, "Muting the Hype Over Hypersonics: The Offense-Defense Balance in Historical Perspective," *War on the Rocks*, May 28, 2019, <https://warontherocks.com/2019/05/muting-the-hype-over-hypersonics-the-offense-defense-balance-in-historical-perspective/>; Alan Cummings, "Hypersonic Weapons: Tactical Uses and Strategic Goals," *War on the Rocks*, Nov. 12, 2019, <https://warontherocks.com/2019/11/hypersonic-weapons-tactical-uses-and-strategic-goals/>; Sydney J. Freedberg Jr., "Hypersonics: DoD Wants 'Hundreds of Weapons' ASAP," *Breaking Defense*, April 24, 2020, <https://breakingdefense.com/2020/04/hypersonics-dod-wants-hundreds-of-weapons-asap/>.

15 Stephen Van Evera, "Offense, Defense, and the Causes of War," in *The Use of Force: Military Power and International Politics*, ed. Robert J. Art and Kenneth N. Waltz, 5th ed. (New York: Rowman and Littlefield Publishers, 1999), 44–69; and Eugene Gholz, "Emerging Technologies' Potential to Change the Balance of Power in Asia," in *Emerging Critical Technologies and Security in the Asia-Pacific*, ed. Richard A. Bitzinger (London: Palgrave MacMillan, 2016), 53–62.

16 See, for example, arguments about longevity and democracy in Dan Reiter and Alann C. Stam, *Democracies at War* (Princeton, NJ: Princeton University Press), chap. 6.



thus more able to inflict damage on an enemy that could cause it to capitulate.¹⁷ Second, new technologies may expand the range of options a decision-maker has when deciding how to prosecute a war. New wartime strategies may be devised that allow for the more efficient allocation of resources or the ability to launch a devastating first strike. Technology, therefore, may alter the list of possible targets and hold at risk sites previously thought safe, resulting in warfighting advantages.

Put more simply, more precise weapons, capable of inflicting the same amount of damage while limiting costs, may reduce the requirements on resolve and intent thought to be especially important in deterrence and coercion.

Naturally, there are also costs to any decision about weapons acquisitions and new technology. The obvious cost is financial in nature. Budgets reflect priorities, and in a world of finite resources, dedicating funding to a new weapons system necessarily means depriving other initiatives of monies and resourcing. These decisions are relevant both to research and development as well as to acquisitions, although the acquisitions process, in many cases, is more significant. Acquiring weapons systems means committing funding toward the purchase and maintenance of these systems not just for a single fiscal year but for multiple years and even decades.¹⁸ New weapons systems also come with a cost to manpower in the form of training and maintenance. Every new technology must be learned, which can require thousands of man-hours to train and equip personnel to understand and use the new system. This usually requires training periods and the development of new expertise, and, in rare cases, has resulted in the introduction of entirely new career specialties.

These actions are not costless to an organization and must be weighed against the expected value of the technology. As a result, decision-makers must look ahead, not just to what capabilities new weapons systems will offer in the near term, but whether those investments will be worthwhile and financially sustainable in five or 10 or 20 years.

Because of the combination of speed and maneuverability, one of the primary advantages of hypersonic missiles lies in their ability to quickly damage air defenses and other command-and-control facilities that were previously thought to be secure with area and point missile defenses.¹⁹ In particular, medium- and short-range hypersonic weapons — e.g., Russia's Kh-47M2 Kinzhal ballistic missile and 3M22 Zircon scramjet or China's WU-14 glide vehicle — provide significant warfighting advantages as they are expected to be able to evade U.S.,

NATO, and partner regional missile defense systems such as the Phased Array Tracking Radar to Intercept on Target (a.k.a., Patriot), the Terminal High Altitude Area Defense (THAAD), and the Aegis.²⁰ The effect is that hypersonic capabilities enable states to increase the speed of conflict. Rather than trying to overwhelm missile defense systems with more vulnerable cruise missiles and medium-range ballistic missiles, which would spark a response and potentially provide enough time for the target state to mobilize, hypersonic missiles enable the rapid destruction of defenses in order to facilitate quick offensive action. If Russia were to employ hypersonic weapons, it would significantly increase the probability of victory in the Baltics, where these weapons could more easily disable the Patriot systems in Europe and Aegis ballistic missile defense systems offshore.²¹ Similarly, the use of hypersonic weapons could significantly increase China's probability of victory over Taiwan due to their ability to penetrate carrier strike group defenses.²² When employed in scenarios in which a

17 The classic example of this is nuclear weapons, best articulated by Bernard Brodie, *Strategy in the Missile Age* (Santa Monica, CA: RAND Corporation, 1959).

18 For a brief overview of the acquisition process, see Heidi M. Peters and Brendan W. McGarry, "Defense Primer: Procurement," Congressional Research Service, updated Dec. 9, 2021, <https://fas.org/sgp/crs/natsec/IF10599.pdf>.

19 Aaron Mehta, "3 Thoughts on Hypersonic Weapons from the Pentagon's Technology Chief," *Defense News*, July 16, 2018, <https://www.defensenews.com/air/2018/07/16/3-thoughts-on-hypersonic-weapons-from-the-pentagons-technology-chief/>.

20 Abraham Mahshie, "Hypersonics Defense," *Air Force Magazine*, Jan. 19, 2022, <https://www.airforcemag.com/article/hypersonics-defense/>; and Sam LaGrone, "MDA: U.S. Aircraft Carriers Now at Risk from Hypersonic Missiles," *USNI News*, updated June 15, 2021, <https://news.usni.org/2021/06/14/mda-u-s-aircraft-carriers-now-at-risk-from-hypersonic-missiles>.

21 Sebastien Roblin, "Russia Deploys Hypersonic Missile to Baltic in Range of NATO Capitals," *Forbes*, Feb. 8, 2022, <https://www.forbes.com/sites/sebastienroblin/2022/02/08/russia-deploys-hypersonic-missile-to-baltic-in-range-of-nato-capitals/?sh=1de31e9d217e>.

22 Kris Osborn, "Could China's New Hypersonic Weapon Block the U.S. from Saving Taiwan?" *National Interest*, Dec. 2, 2021, <https://nationalinterest.org/blog/buzz/could-china-s-new-hypersonic-weapon-block-us-saving-taiwan-197356>.

state is using a *fait accompli* strategy, therefore, hypersonic weapons significantly change the likelihood of victory because they render previously secure targets vulnerable, thus changing the balance of power on the battlefield.

By contrast, the warfighting advantages of hypersonic weapons from a defensive posture are less pronounced. When the aim is to defend territory that is already under attack, surprise and speed are no longer critical requirements, and so slower, more traditional weapons systems are more viable. Indeed, no missile defense system is impenetrable or perfectly reliable, and so quantity can be a quality all on its own, given enough time and resources. Hypersonic weapons are therefore more easily substituted with other, more traditional weapons employed in large numbers, or by using stealth technology that can evade missile defense early radars during a retaliatory strike. American F-35s, for example, are expected to be able to penetrate Russian defense systems like the S-400 and Chinese air defenses like the HQ-19, thus increasing the probability of a successful strike even using existing missiles.²³ Indeed, exercises at Red Flag suggest that the type of missile the F-35 is carrying matters less than the aircraft's ability to evade sensors while carrying enough inventory to overwhelm defensive systems.²⁴ The strategy may not be as efficient, but it is executable all the same.

In conflicts that do not involve great powers, hypersonic weapons introduce new capabilities and open up new potential targets because their use does not require a significant buildup of forces prior to launch. As such, leadership decapitation suddenly becomes a more viable strategy, particularly against regimes without resilient command-and-control structures.²⁵ Additionally,

the targeting of mobile, and at-times elusive targets, such as terrorist leaders (especially those who operate with the tacit support of their base country), becomes easier and more effective.²⁶ As with great-power rivalry, the primary advantage of hypersonic weapons in non-great power conflicts appears to be their ability to execute quick, precise strikes with little to no warning.

The costs associated with procuring hypersonic weapons, however, have far exceeded initial estimates. Early on, there were suggestions that hypersonic weapons could be produced cheaply and efficiently. However, over the last several years, the Pentagon has been steadily increasing the amount of funding it seeks in order to pursue hypersonic weapons.²⁷ Its FY21 budget included a request for \$3.2 billion in hypersonic research, with contracts with Lockheed Martin estimated to cost \$1.1 billion.²⁸ Recent estimates suggest that hypersonic missiles could cost \$106 million per missile for the Army and \$89.6 million per missile for the Navy — an increase of \$7 billion and \$21.5 billion to each service's respective budget.²⁹ By contrast, cruise missile technology currently costs a little more than \$1 million per unit and the Navy already has more than 4,000 in inventory (though it plans to replace and dismantle many of them).³⁰ Additionally, while acquiring hypersonic weapons is unlikely to increase costs associated with training, there is already concern that the "rapid growth in hypersonic research has the potential to result in stove-piped, proprietary systems that duplicate capabilities and increase costs."³¹ In response, Congress appropriated \$100 million to establish a Joint Hypersonic Transition Office to, "establish a university consortium for hypersonic research and workforce development."³² The financial cost of

23 Deborah Lee James and Daniel Gouré, *The Implications of Fifth-Generation Aircraft for Transatlantic Airpower: A Primer*, Atlantic Council, Oct. 7, 2019, <https://www.atlanticcouncil.org/in-depth-research-reports/report/the-implications-of-fifth-generation-aircraft-for-transatlantic-airpower-a-primer/>.

24 James Kitfield, "Red Flag 2019: First Great Power Air War in Years," *Breaking Defense*, March 6, 2019, <https://breakingdefense.com/2019/03/red-flag-2019-first-great-power-air-war-test-in-years/>.

25 Speier et al., *Hypersonic Missile Nonproliferation*; and R. Jeffrey Smith, "Hypersonic Missiles Are Unstoppable. And They're Starting a New Global Arms Race," *New York Times*, June 19, 2019, <https://www.nytimes.com/2019/06/19/magazine/hypersonic-missiles.html>.

26 Acton, *Silver Bullet?*

27 Joseph Trevithick, "Here's How Hypersonic Weapons Could Completely Change the Face of Warfare," *The War Zone*, 2017, last updated July 5, 2020, <https://www.thedrive.com/the-war-zone/11177/heres-how-hypersonic-weapons-could-completely-change-the-face-of-warfare>.

28 Kelley Saylor, *Hypersonic Weapons: Background and Issues for Congress*, Congressional Research Service, Report R45811, updated July 20, 2022, <https://fas.org/sgp/crs/weapons/R45811.pdf>.

29 Anthony Capaccio, "Hypersonic Sticker Shock: U.S. Weapons May Run \$106 Million Each," *Bloomberg News*, Nov. 12, 2021, <https://www.bloomberg.com/news/articles/2021-11-12/hypersonic-sticker-shock-u-s-weapons-may-run-106-million-each>; Sebastien Roblin, "The Pentagon Plans to Deploy an Arsenal of Hypersonic Weapons in the 2020s," *Forbes*, April 30, 2020, <https://www.forbes.com/sites/sebastienroblin/2020/04/30/the-pentagons-plans-to-deploy-an-arsenal-of-hypersonic-weapons-in-the-2020s/?sh=20e81913a5d7>.

30 David Axe, "America's Tomahawk Cruise Missiles Is Shrinking—And Fast," *National Interest*, July 27, 2021, <https://nationalinterest.org/blog/reboot/americas-tomahawk-cruise-missiles-shrinking—and-fast-190597>.

31 Saylor, *Hypersonic Weapons*.

32 Saylor, *Hypersonic Weapons*.



hypersonic weapons, therefore, could be significant and may actually undermine other, more efficient modernization efforts.

Strategic Effects of New Technologies

In addition to warfighting advantages, new technologies can also have strategic effects on the likelihood of war, how states interact, and the ability of states to coerce and deter in the international arena. Indeed, changes in the balance of power on the battlefield affect negotiations during war, but more importantly, they affect a state's willingness to go to war in the first place.³³ This happens in two broad ways: by influencing a state's ability to coerce and/or deter adversaries, and by influencing a state's ability to signal its intentions, capabilities, and resolve.

New technology can impact a state's ability to deter or coerce in a variety of ways. Perhaps most intuitively, new technologies can alter the balance of power, making one state significantly more likely to win should war break out. This change in power then increases a state's leverage and its ability to either impose its will on another state or deter a state from potentially aggressive actions.³⁴ A number of capabilities produce significant changes in the balance of power, including destructive capacity and warfighting potential. The ability of a state to destroy its adversary with little effort once provoked is a powerful disincentive for engaging in hostile behavior. The size of the punishment — or the destructive capability of the weapon — that a state has available is therefore related to a state's ability to deter and coerce.³⁵

The ability to wage war precisely and accurately also changes the balance of power as states seek to target military vulnerabilities while minimizing collateral damage and effort. Weapons that are more precise and more accurate increase the number

of targets that are available while decreasing the number of missiles needed to destroy any given target. Power is therefore both the ability to destroy but also the ability to sustain a campaign. Put more simply, more precise weapons, capable of inflicting the same amount of damage while limiting costs, may reduce the requirements on resolve and intent thought to be especially important in deterrence and coercion.³⁶

Finally, new technologies may also alter the balance of power by changing the ability of a state to absorb attacks. This applies to weapons systems that improve defenses, but also to those that render existing defenses obsolete. While both the destructive potential of a weapon and the ability to prosecute a lengthy campaign alter a state's ability to punish its adversary (and thereby alter strategic calculations about the desirability of engaging in provocation), changes in defensive capabilities influence a state's ability to deny its adversary the ability to successfully attack at all.³⁷

However, these strategic advantages can also come with significant costs. Indeed, certain types of technologies may be especially provocative and destabilizing if they create significant first-strike advantages. When a particular technology is thought to create significant advantages for the aggressor, it can result in first-strike instability — where each side in a conflict has a strong incentive to fire first lest it fire too late.³⁸ This concept is most thoroughly developed in the realm of nuclear strategy, where a nuclear first strike could render an adversary not just defenseless but decimated.³⁹ However, similar principles may also be applied to technologies that increase the probability of successful decapitation strategies that would remove a ruling regime from power and other measures that would substantially alter a state's power.⁴⁰

The introduction of new, offense-dominant technologies may also have second-order effects as

33 Kenneth N. Waltz, *Theory of International Politics* (New York: McGraw Hill, 1979).

34 For a formalized model, see James Fearon, "Rationalist Explanations for War," *International Organization* 49, no. 3 (Summer 1995): 379–414, <https://www.jstor.org/stable/2706903>.

35 Thomas C. Schelling, *Arms and Influence* (New Haven, CT: Yale University Press, 1966), 12–34.

36 Fred Charles Iklé, *How Nations Negotiate* (New York: Harper and Row, 1964); Schelling, *Arms and Influence*; Robert Jervis, *The Logic of Images in International Relations* (Princeton, NJ: Princeton University Press, 1970); Robert E. Osgood and Robert W. Tucker, *Force, Order, and Justice* (Baltimore, MD: Johns Hopkins University Press, 1967); Alexander L. George, *The Limits of Coercive Diplomacy* (New York: Little Brown & Company, 1971); Andrew Mack, "Why Big Nations Lose Small Wars: The Politics of Asymmetric Conflict," *World Politics* 27, no. 2 (January 1975): 175–200, <https://doi.org/10.2307/2009880>; and Michael Russell Rip and James M. Hasik, *The Precision Revolution: GPS and the Future of Aerial Warfare* (Annapolis, MD: Naval Institute Press, 2022).

37 Glenn Snyder, *Deterrence by Denial and Punishment* (Princeton, NJ: Center of International Studies, 1959); Brodie, *Strategy in the Missile Age*, 173–222; and Robert A. Pape, *Bombing to Win: Air Power and Coercion in War* (Ithaca, NY: Cornell University Press, 1995).

38 Thomas C. Schelling, *The Strategy of Conflict* (Cambridge, MA: Harvard University Press, 1960), chap. 10.

39 Schelling, *Arms and Influence*.

40 Schelling, *The Strategy of Conflict*.

states take pains to preserve their second-strike capabilities and make their defenses more resilient.⁴¹ If, for example, the introduction of a new technology makes a state less secure in its command-and-control structure, it may take pains to disperse and decentralize those capabilities and decision-making authorities about the use of force.⁴² Similarly, a new technology that decreases the amount of time that a state has to make a decision about whether and how to retaliate may force states to adopt a “hair trigger” warning, where the slightest provocation is met with retaliatory measures without having to gain approval from higher levels of authority.⁴³

In addition to altering the balance of power, new technologies can influence deterrence and coercion by improving the credibility of a threat.⁴⁴ States that only possess weapons whose use would constitute a disproportionate response find themselves lacking credibility.⁴⁵ This is, of course, most applicable to the threat to use nuclear weapons, where any use in response to a conventional conflict would represent both a severe breach of international norms and a severe escalation.⁴⁶ Indeed, while threatening to use a nuclear weapon in the face of a minor border incursion is inherently not credible (and thus does little to deter an adversary), threats to use a more proportionate weapon system are inherently more credible and thus increase a state’s ability to deter unwanted behavior.⁴⁷

New technology influences not just a state’s ability to deter or coerce an adversary, but also its ability to signal its intentions. James Fearon has highlighted that information asymmetry — that is, discrepancies in information about an adversary’s capabilities or intent — is one of very few

reasons why rational states would choose to go to war rather than negotiate.⁴⁸ New technologies can either illuminate or obfuscate information about a state’s capabilities and intentions — and thus, alter its ability to signal and communicate in the international arena.⁴⁹ Improvements in reconnaissance and surveillance, for example, can lower the probability of war by providing additional information about an adversary’s posture and capabilities. Secret improvements in a state’s offensive capabilities, however, can increase the probability of war because that state’s adversaries are misinformed about its relative power.⁵⁰ Furthermore, the mere presence of a technology can alter the strategic calculations of an adversary in destabilizing ways. This can have profound consequences on estimations about another state’s intentions and the likelihood of conflict.⁵¹ If, for example, a particular technology can be used both for significant offensive as well as defensive capabilities, an adversary has little way of knowing for sure how that technology might be used and must assume that it will be used for offensive measures.⁵² Thus, even a technology that is intended to improve a state’s defensive security capabilities can trigger conflict spirals as other states feel less secure — a concept known as the security dilemma.⁵³

As states respond to the uncertainty produced by these new technologies, their mitigation efforts can significantly increase their own risk of misinterpreting an adversary’s actions. These misinterpretations, when coupled with decentralized decision-making authorities, then significantly increase the probability of an accidental war — the initiation of a conflict against the desire of the

41 Vipin Narang, *Nuclear Strategy in the Modern Era: Regional Powers and International Conflict* (Princeton, NJ: Princeton University Press, 2014).

42 Narang, *Nuclear Strategy in the Modern Era*.

43 Narang, *Nuclear Strategy in the Modern Era*.

44 Schelling, *Arms and Influence*, chap. 2; and Fearon, “Rationalist Explanations for War.”

45 Schelling, *Arms and Influence*, 43–49.

46 For a discussion of international norms surrounding the use of nuclear weapons, see Nina Tannenwald, “The Nuclear Taboo: The United States and the Normative Basis of Nuclear Non-Use,” *International Organization* 53, no. 3 (Summer 1999): 433–68, <https://www.jstor.org/stable/2601286>; Daryl G. Press, Scott D. Sagan, and Benjamin A. Valentino, “Atomic Aversion: Experimental Evidence on Taboos, Traditions, and the Non-Use of Nuclear Weapons,” *American Political Science Review* 107, no. 1 (February 2013): 188–206, <https://doi.org/10.1017/S0003055412000597>.

47 It is worth noting, however, that Brodie points to a key case in which the threat to use nuclear weapons, even in relatively minor instances, still may be credible due to the sheer consequences of nuclear weapons should a state misperceive its aggressor’s intentions. In this way, because the consequences of miscalculation are so high, even threats that would seem to be ridiculous are treated as credible if there is even a chance that the threatening state could or would follow through. Brodie, *Strategy in the Missile Age*, 278.

48 Fearon, “Rationalist Explanations for War.”

49 For an overview of signaling in foreign policy, see James D. Fearon, “Signaling Foreign Policy Interests: Tying Hands Versus Sinking Costs,” *Journal of Conflict Resolution* 41, no. 1 (1997): 69–90, <https://doi.org/10.1177/2F0022002797041001004>.

50 Brendan Rittenhouse Green and Austin Long, “Conceal or Reveal? Managing Clandestine Military Capabilities in Peace Competition,” *International Security* 44, no. 3 (Winter 2019/2020): 48–83, https://doi.org/10.1162/isec_a_00367.

51 Robert Jervis, “Cooperation Under the Security Dilemma,” *World Politics* 30, no. 2 (January 1978): 167–214, <https://doi.org/10.2307/2009958>.

52 Jervis, “Cooperation Under the Security Dilemma.”

53 Robert Jervis, *Perception and Misperception in International Politics* (Princeton, NJ: Princeton University Press, 1976).



countries' leaders.⁵⁴ Similarly, when new technologies obscure a state's ability to signal intent and resolve, they could inadvertently escalate a conflict far beyond their initial limited objectives.⁵⁵ This is because states have both less information about their adversaries' intent (and therefore must always assume the worst) and less ability to absorb a first strike before deciding to retaliate. As a result, the use of new technology could potentially cause an initially limited conflict to spiral into total war due to the inability to distinguish between limited and unlimited attacks.

Finally, new technologies can have strategic effects through signaling about resolve. Technologies that automate decision-making away from humans — who are capable of both malice and indecision — can significantly increase the credibility of a state's resolve to show restraint or retaliate.⁵⁶ Understanding how a particular technology may contribute to a state's ability to signal resolve, therefore, is critical to making determinations about acquiring new technology. After all, it would hardly be advantageous to acquire a "Doomsday Machine" if one were going to keep it a secret — rather than using it to signal to one's adversary that any deployment of nuclear weapons will be met with world-ending force.⁵⁷

Strategic Effects of Hypersonic Weapons

Will hypersonic weapons have a strategic effect? On the surface, the destructive potential of hypersonic weapons is no greater than any other missile or any warhead that could be put on such a missile. As a result, it is unlikely to carry an additional threat in terms of its ability to deter an adversary on the basis of destructive potential alone. However, hypersonic weapons may increase the credibility of a threat precisely because they do not have to carry nuclear warheads — or any warhead at all, for that matter.⁵⁸ Because hypersonic missiles travel at such great speeds, the size of the explosion upon impact can approximate that of many conventional warheads. Indeed, the ability of inter-continental

hypersonic missiles to successfully attack conventional targets — a concept known as Conventional Prompt Global Strike — may decrease the cost of such an offensive to the point where U.S. threats against adversaries across the world may be perceived as significantly more credible than before.⁵⁹

Hypersonic missiles may also increase the credibility of a state's threats in other ways. There is currently no defense against hypersonic missiles, which makes deterrence by denial much more difficult. Because the United States and its allies possess relatively advanced missile defense systems, it is difficult for Russia and China to issue credible threats in today's security environment. However, by acquiring hypersonic missiles, Russia and China are able to mitigate the challenges created by missile defense systems and increase the probability of military success, thus making their threats more credible. The impact of America possessing hypersonic weapons, however, is less clear, given the uneven nature of Russian and Chinese missile defense systems. For regional conflicts involving U.S. allies and partners where Russian and Chinese systems are most advanced, hypersonic capabilities will likely increase the credibility of U.S. threats. However, that increase is likely to be less than currently imagined for reasons discussed in the above section on warfighting advantages. For inter-continental conflict, there is likely to be very little difference in credibility, given the still-limited long-range anti-ballistic missile programs of other great powers.⁶⁰ Hypersonic missiles therefore appear far more likely to improve the credibility of threats against the United States and its allies and partners, than they are to significantly improve the credibility of American threats.

By contrast, the acquisition of hypersonic weapons may harm America's credibility with alliance partners. An increased ability to reach across the globe quickly may decrease America's need for a forward posture and basing around the world. This, in turn, may create problems for allies that have traditionally relied on the presence of U.S.

54 Schelling, *The Strategy of Conflict*, 188.

55 Barry R. Posen, *Inadvertent Escalation: Conventional War and Nuclear Risks* (Ithaca, NY: Cornell University Press, 1994).

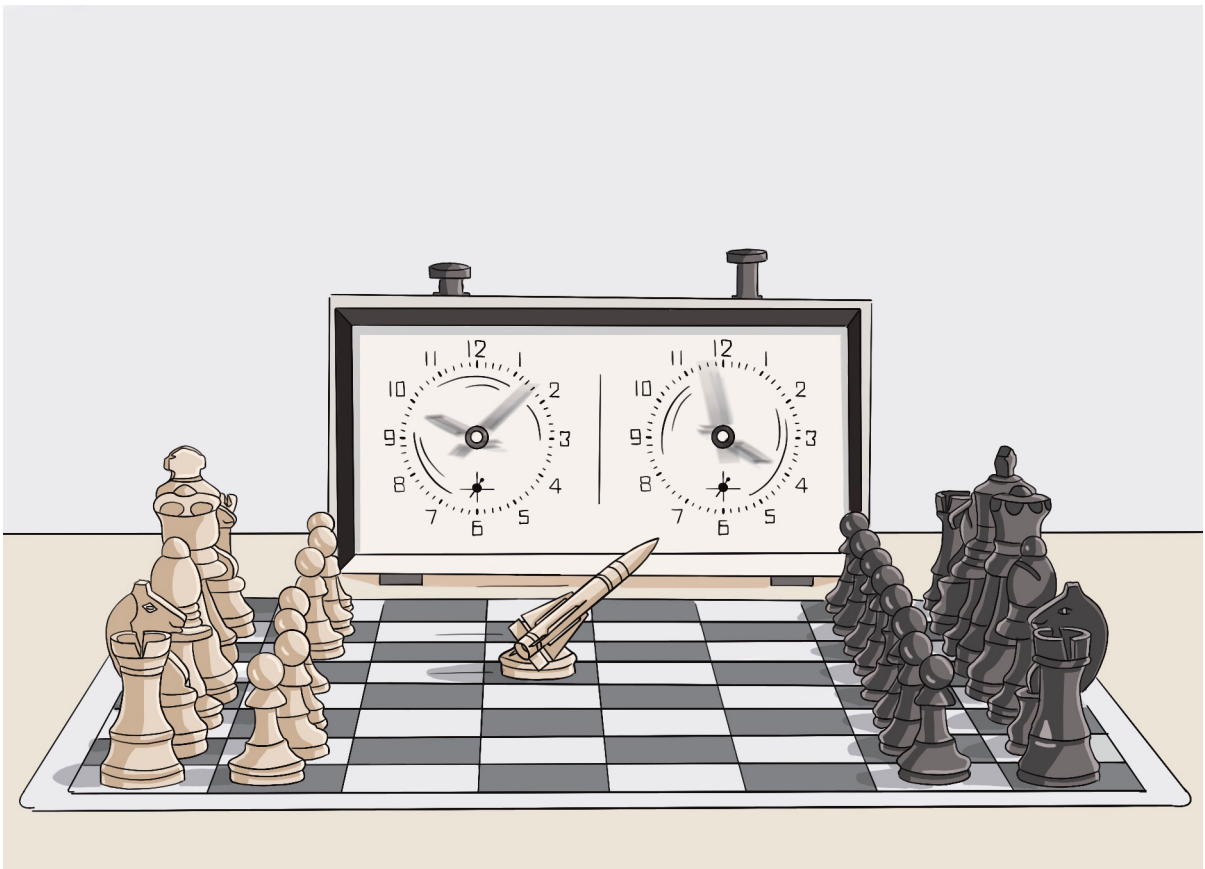
56 Schelling, *The Strategy of Conflict*, chap. 8; and Schelling, *Arms and Influence*, chap. 3.

57 Herman Kahn initially gave Stanley Kubrick the idea for the infamous "Doomsday Machine" that threatened to destroy the world in "Dr. Strangelove or: How I Learned to Stop Worrying and Love the Bomb," directed by Stanley Kubrick (Columbia Pictures, 1964).

58 Acton, *Silver Bullet?*

59 Acton, *Silver Bullet?*

60 While Russian missile defense systems are fairly sophisticated around Moscow (as permitted by the now-defunct Anti-Ballistic Missile Treaty), China has only recently introduced area defense systems capable of intercepting medium- and intermediate-range missiles. The author is unaware of any functional Chinese long-range anti-ballistic missile programs.



forces to deter aggression from regional powers and adversaries.⁶¹ Decreased confidence in America's commitment to collective defense in Europe and East Asia could therefore result in a series of destabilizing measures as states attempt to ensure their own security.⁶² Many of the medium- and intermediate-range hypersonic weapons currently under development in the United States, like the Common Hypersonic Glide Body and the Air-Launched Rapid Response Weapon (better known as ARRW), are being designed specifically with regional conflicts in mind, which has the potential to mitigate such assurance concerns. However, Rupal Mehta points out that even this may not be enough to reassure allies because America's possession of hypersonic weapons could provoke China and

Russia. She writes that "allies may fear that even conventional-only hypersonic vehicles may increase the risk of conflict to unacceptable levels — producing uncertainty about whether they would actually be used in combat."⁶³ Indeed, the lack of widespread demand from U.S. allies for hypersonic weapons technology transfers — despite their apparent utility in regional conflicts — suggests that these weapons could cause significant issues to arise between allies.

What's more, hypersonic weapons will likely have a negative impact on a state's ability to signal intent. As with all new technologies, there are no established norms for the use of hypersonic weapons,⁶⁴ which could lead to ambiguities about a state's intent during a crisis. This could, in turn, have potentially

61 Marc Trachtenberg, *A Constructed Peace: The Making of the European Settlement, 1945–1963* (Princeton, NJ: Princeton University Press, 1999); Jesse C. Johnson and Brett Ashley Leeds, "Defense Pacts: A Prescription for Peace?" *Foreign Policy Analysis* 7, no. 1 (January 2011): 45–65, esp. 45; Brett Ashley Leeds, "Do Alliances Deter Aggression? The Influence of Military Alliances on the Initiation of Militarized Interstate Disputes," *American Journal of Political Science* 47, no. 3 (July 2003): 427–39, <https://doi.org/10.1111/1540-5907.00031>; Paul K. Huth, "Extended Deterrence and the Outbreak of War," *American Political Science Review* 82, no. 2 (June 1988): 423–43, <https://doi.org/10.2307/1957394>; and Vesna Danilovic, "The Sources of Threat Credibility in Extended Deterrence," *Journal of Conflict Resolution* 45, no. 3 (June 2001): 341–69, <https://doi.org/10.1177/2F0022002701045003005>.

62 Francis J. Gavin, "Strategies of Inhibition: U.S. Grand Strategy, the Nuclear Revolution, and Nonproliferation," *International Security* 40, no. 1 (Summer 2015): 9–46, https://doi.org/10.1162/ISEC_a_00205.

63 Mehta, "Extended Deterrence and Assurance."

64 For a discussion of the difficulties associated with new technology and signaling, see James D. Morrow, "International Law and the Common Knowledge Requirements of Cross-Domain Deterrence," in *Cross-Domain Deterrence: Strategy in an Era of Complexity*, ed. Jon R. Lindsay and Erik Gartzke (New York: Oxford University Press, 2019).



catastrophic consequences. In particular, the inability of a target state to identify early on where a missile is intended to hit can cause significant problems for strategic stability. The combination of the speed and maneuverability of hypersonic weapons means that target states will be forced to assume that such an attack will hit command-and-control facilities and must therefore take measures to prevent the loss of its retaliatory capabilities.

These operational adjustments could negatively impact strategic stability in three ways. First, they increase the risk of accidentally deploying or using a nuclear weapon. No deployment or alert is 100 percent safe, and the law of large numbers suggests that the more often nuclear weapons are forward-positioned or alerted, the more likely it is that an accident will take place.⁶⁵ Second, they increase the potential for inadvertent escalation as adversaries may misinterpret a state's actions as aggressive, escalatory, or preparation for war when, in fact, they simply reflect the appropriate force posture given the compressed decision-making timeline — a classic security dilemma with the potential for escalation.⁶⁶ Finally, this compressed timeline alters the incentives of decision-makers in ways that encourage a leader to “shoot first and ask questions later.” Given the cost of delay to a state's second-strike capabilities, there is already very little time to question an adversary's intentions or whether the warning data is verified. With a decision-making timeline that is generously estimated at a quarter of what it is now, leaders will have little choice but to adopt “launch on warning” postures that leave little room for error.⁶⁷

Uncertainty about what type of explosive a missile is carrying, also known as warhead ambiguity, can also contribute to information asymmetries, which can lead to war. Nuclear signaling has traditionally been straightforward, particularly between inter-continental adversaries. Only certain types of bombers are capable of dropping nuclear weapons, and only certain types of missiles carry nuclear payloads. As a result, countries are able to clearly interpret a state's intention when those weapons are activated and deployed. But hypersonic weapons present a challenge precisely because they can deliver both conventional and nuclear payloads.

As a result, a target state would be unable to discern whether an incoming hypersonic weapon was intended as a nuclear strike or a more modest conventional one and might be forced to prepare for an incoming nuclear strike, which could lead to significant escalation beyond the attacking state's intent. These issues are compounded by target ambiguity. Take, for example, an attempted U.S. strike on a remote terrorist target in northern Pakistan — exactly the type of strike that the United States has identified as a candidate for a hypersonic missile launch.⁶⁸ The geography and political instability of the region means that three nuclear powers would detect an incoming missile from the United States and be unable to determine whether the missile was intended for their territory, and whether it was carrying a conventional or nuclear payload. This scenario has the potential not just to exacerbate tensions in a highly volatile area, but to mobilize three of the world's most powerful militaries precisely because of ambiguities in signaling.

The United States is also potentially at risk of misinterpreting the intent of a potential adversary due to information asymmetries. Unlike the United States, both Russia and China have declared their intention to use hypersonic weapons to modernize their nuclear arsenal. Given that most hypersonic missiles are able to carry both conventional and nuclear warheads, it may be much more difficult for Russia or China to signal its intent to keep the war limited in the event of a conflict. Indeed, despite America's declared intention to use hypersonic weapons exclusively for conventional strikes, U.S. leaders still may not have a credible way of signaling a non-nuclear mission in the absence of independent verification through an arms control regime.⁶⁹ Any missile warning for areas around U.S. entities or allies in the Pacific places America's interests at extreme risk — and potentially forces U.S. forces to adopt a more aggressive posture in response.

There are additional strategic costs to developing hypersonic missiles. While second-strike capabilities are likely to remain secure for nuclear weapons powers, employing hypersonic weapons would jeopardize a target state's ability to protect and retain command-and-control structures in the event of an attack, thereby reintroducing

65 Scott D. Sagan, *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons* (Princeton, NJ: Princeton University Press, 1995).

66 Posen, *Inadvertent Escalation*. For an updated assessment of inadvertent escalation regarding U.S.-Chinese relations, see 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.

67 Speier et al., *Hypersonic Missile Nonproliferation*; and Narang, *Nuclear Strategy in the Modern Age*.

68 Acton, *Silver Bullet?*

69 Talmadge, “Would China Go Nuclear?”

decapitation as a viable strategy under certain circumstances.⁷⁰ In countries with defined protocols and procedures for the orderly transition of power, this may not present a particular problem.⁷¹ However, regimes that concentrate power at the top with a single person or family and do not have a clear line of succession — what we might call personalist regimes — may be more vulnerable.⁷² These vulnerable states may take preventive measures, which could have significant second- and third-order effects and increase the likelihood of accidental war. To ensure regime survival and increase the credibility of a second strike, some regimes may delegate nuclear authorizations into the hands of operational commanders. This delegation of authority could ensure that a state will retaliate if struck, but it would also necessarily increase the risks associated with rogue actors or accidental detonation.⁷³ More research is needed to assess likely adversary responses to hypersonic weapons and the effect on strategic stability.

Overall, the benefits of acquiring hypersonic weapons appear to be highest for countries attempting to defeat the kind of advanced missile defense systems that might prevent aggressive *fait accompli* strategies. Dominant powers and powers without revisionist ambitions (who therefore do not need the element of surprise) have less to gain from their acquisition and more reason to worry about the costs associated with the introduction of these weapons into the global system.

Pursuing Arms Control: Theoretical Considerations and Applications for Hypersonic Weapons⁷⁴

The second policy debate that surrounds the emergence of new technology is whether a state should pursue a nonproliferation agenda with regard to that technology. While the two policy questions — acquisition and nonproliferation — are related, they are in fact theoretically distinct and

guided by different logics. For example, while the United States has both acquired nuclear weapons and maintained a robust nonproliferation regime, it has sought to acquire artificial intelligence capabilities with little accompanying nonproliferation initiatives. Similarly, America has largely disposed of low-yield “tactical” nuclear weapons and has been vocal about its desire for an arms control treaty that includes non-strategic nuclear weapons, but it has not pursued a similar arms control agreement for super-sonic missiles, which it does not have in its active inventory. The choice to acquire a given technology, therefore, is distinct from the decision to try to limit its spread around the world.

In general, decisions about pursuing arms control are made by analyzing the strategic effects, domestic incentives, and potential costs associated with nonproliferation. Arms control agreements can take many forms in order to solve one or more issues that these considerations present: They may seek to simply produce information about a country’s stockpiles, limit the spread of the technology, or ban outright the production and/or testing of the technology. Each agreement, therefore, is designed to mitigate as much as possible the problems the technology creates for international cooperation and stability, recognizing both the domestic and international costs and constraints.

Solving Strategic Instability

Most of the arms control literature focuses on strategic reasons to pursue a nonproliferation agenda — that is, using arms control as a means of preventing war and conflict. This class of considerations can be divided into roughly two categories: solving information asymmetries and addressing concerns about the balance of power. Incomplete and imperfect information is widely seen as the primary driver of conflict, and it is therefore usually in states’ interests to resolve any information asymmetries between them.⁷⁵ Arms control agreements, by virtue of their monitoring mechanisms,

70 Lee, “Asking the Right Questions”; and Speier et al., *Hypersonic Missile Nonproliferation*.

71 Jenna Jordan, *Leadership Decapitation: Strategic Targeting of Terrorist Organizations* (Stanford, CA: Stanford University Press, 2019); and Austin Long, “Whack-a-Mole or Coup de Grace? Institutionalization and Leadership Targeting in Iraq and Afghanistan,” *Security Studies* 23, no. 3 (2014): 471–512, <https://doi.org/10.1080/09636412.2014.935229>.

72 See Barbara Geddes, *Paradigms and Sand Castles: Theory Building and Research Design in Comparative Politics* (Ann Arbor: University of Michigan Press, 2002), for a fuller description of regime types, particularly for autocracies.

73 Scott D. Sagan, “The Perils of Proliferation: Organization Theory, Deterrence Theory, and the Spread of Nuclear Weapons,” in *Civil-Military Relations and Nuclear Weapons*, ed. Scott D. Sagan (Stanford, CA: Center for International Security and Arms Control, June 1994), https://cisac.fsi.stanford.edu/publications/civilmilitary_relations_and_nuclear_weapons.

74 I use the terms “nonproliferation” and “arms control” interchangeably in this article for purposes of colloquial illustration. In fact, nonproliferation is a specific subset of arms control that limits the spread of weapons or technology. There are a host of other initiatives, including technology bans, numerical limits, and monitoring mechanisms, that fall under the category of arms control as well and are included in the theoretical considerations outlined in this section.

75 Fearon, “Rationalist Explanations for War.”

in many ways resolve this issue. Similarly, changes in the balance of power are widely recognized to cause conflict as declining powers feel the need to act quickly to prevent challengers from gaining more strength (what is colloquially known as the Thucydides Trap).⁷⁶

Information asymmetries create problems for states because they are unable to bargain over contested issues without knowing the other sides' capabilities, intent, and resolve.⁷⁷ Without good information on how powerful an adversary is, a state may believe that it could win a war that in reality it was unprepared to fight. Information about an opponent's capabilities is therefore critical to decision-making. Similarly, information about an adversary's resolve and intent influences the probability of war. Many actions in the international arena can be interpreted either as hostile and aggressive or as stabilizing. For example, humanitarian missions abroad could either be a pretext for removing unfriendly governments, or a good-faith effort to prevent the creation and radicalization of refugees. Intent regarding the use of power matters.

Arms control agreements work to reduce these kinds of information asymmetries in two important ways. First, arms control agreements can provide leaders with visibility on the capabilities of other countries, particularly when it comes to technologies that are especially destructive or capable of inflicting significant harm. They can allow leaders to assess more accurately the threat level coming from a particular state with regard to a particular technology. This reduces the probability that states will miscalculate and begin a war they cannot win.⁷⁸ Alternatively, arms control agreements can allow weaker states to learn more about their adversaries' capabilities and make defensive preparations. It may also give them the opportunity to balance

capabilities in a way that protects the *status quo*.⁷⁹ As a result, new technologies that either significantly alter offensive capabilities in ways that are not easily monitored or reduce a state's ability to signal its capabilities, become targets for arms control as states try to reduce information asymmetries.

Second, arms control agreements can reveal information about a state's intent and resolve. Often, new technology can be used either offensively or defensively. Arms control agreements can help clarify what a state's intention is with respect to the technology's use.⁸⁰ Indeed, arms control agreements themselves are a costly signal that a state is willing to cooperate. By agreeing to sometimes intrusive inspections, states are signaling to the international community that they intend to use the technology for defensive, rather than offensive, purposes.⁸¹ This was indeed the basis for many early arms control agreements between the United States and the Soviet Union. These agreements were seen by many as confidence measures to build trust rather than as true efforts to reduce the number or deployment of nuclear weapons around the globe.⁸² Arms control agreements also provide visibility into how new technologies are being used and deployed. Inspections of a peaceful nuclear program, for example, can reveal much about a state's intent with regard to nuclear weapons proliferation. New technologies that obscure state intentions, or that are capable of both offensive and defensive use, are often the target of arms control agreements as states seek to gain more information about other states' intentions.⁸³

The second issue that arms control agreements are used to address are instabilities in the balance of power in the international system. States jockey for position and power in the international system over time, and stable balances of power emerge

76 Known as power transition theory, this was first popularized in A.F.K. Organski, *World Politics* (New York: Alfred Knopf, 1968). See also Robert Gilpin, *War and Change in World Politics* (Cambridge, UK: Cambridge University Press, 1983); and Graham Allison, *Destined for War: Can America and China Escape Thucydides's Trap?* (New York: Houghton Mifflin Harcourt, 2017). The colloquial phrase "Thucydides Trap" is based on the competition between Athens and Sparta in the Peloponnesian War outlined by Thucydides (see Robert B. Strassler, ed., *The Landmark Thucydides: A Comprehensive Guide to the Peloponnesian War* (New York: Free Press, 1998). For additional theories related to aggression and power transition, see David M. Edelstein, *Over the Horizon* (Ithaca, NY: Cornell University Press, 2017); Joshua R. Itzkowitz Shiffrin, *Rising Titans Falling Giants: How Great Powers Exploit Power Shifts* (Ithaca, NY: Cornell University Press); and Kori Schake *Safe Passage: The Transition from British to American Hegemony* (Cambridge, MA: Harvard University Press, 2017).

77 Fearon, "Rationalist Explanations for War."

78 Thomas C. Schelling and Morton H. Halperin, *Strategy and Arms Control*, Summer Study on Arms Control of the American Academy of Arts and Sciences, Center for International Affairs at Harvard University, 1961.

79 Schelling and Halperin, *Strategy and Arms Control*, 36.

80 Jervis, "Cooperation Under the Security Dilemma."

81 James D. Morrow, "Alliances: Why Write Them Down?" *Annual Review of Political Science* 3, no. 1 (June 2000): 63–83, <https://doi.org/10.1146/annurev.polisci.3.1.63>; and Andrew Kydd, "Trust, Reassurance, and Cooperation," *International Organization* 54, no. 2 (Spring 2000): 325–57, <https://doi.org/10.1162/002081800551190>.

82 Leslie H. Gelb, "A Glass Half Full," *Foreign Policy*, no. 36 (Autumn 1979): 21–32, <https://doi.org/10.2307/1148203>.

83 Schelling and Halperin, *Strategy and Arms Control*.

through alliance maintenance and management.⁸⁴ However, new technology, particularly if only possessed by one state, can dramatically and quickly alter the balance of power in a region or across the world, causing states to become insecure and desire a change. Rapid changes in the balance of power can lead to miscalculation and quick realignment across the world, where increasingly powerful states seek to assert themselves and declining powers seek a rebalance. The most common way that this rebalancing occurs is through war and conflict.⁸⁵ Arms control agreements can prevent this, however, because they limit the spread of new technology and ensure that one side does not grow overly powerful due to technological innovations.

Even if a new technology does not create rapid changes in the balance of power, it still may play a role in facilitating change. Indeed, this is almost entirely the point of investing in new technology — to be more competitive on the battlefield and thus increase one's share of power in the international system.⁸⁶ Arms control agreements can therefore still be useful should a state be interested in preserving the *status quo*. These agreements may vary depending on the type of technology. For example, states with significant power advantages may be particularly interested in pursuing arms control and nonproliferation measures for technology that evens the playing field or is otherwise “democratizing” between states.⁸⁷ By contrast, states already disadvantaged in the international system have an incentive to pursue arms control when dealing with particularly expensive or sophisticated weapons systems that are likely to exacerbate inequalities between states.⁸⁸ As military technology grows increasingly complex, states with low levels of education, skills, and development (also known as human capital) may have strong incentives to limit additional progress.⁸⁹

Finally, arms controls agreements might be considered useful for dominant powers that want to maintain control over smaller and more vulnerable allies. The acquisition of new technologies by smaller allied nations presents new incentives and

opportunities for these allies to engage in provocative behavior that may draw a great power into a war, a problem that principal-agent theorists call moral hazard.⁹⁰ Great powers may therefore have an incentive to pursue nonproliferation agendas for technologies that their allies might use to pursue agendas that differ from their own, in an effort to maintain control and influence in their allies' foreign policies.

As discussed in the previous section, hypersonic weapons introduce significant issues for strategic stability. They increase information asymmetries, complicate signaling between states, and introduce new first-mover advantages that encourage *fait accompli* strategies. Shorter-range missiles in particular pose challenges for stability because they increase the benefits of taking offensive action while reducing the effectiveness of defense. By contrast, longer-range hypersonic gliders, such as the Avangard, may increase strategic stability by ensuring that Moscow has a second-strike capability against U.S. homeland missile defense efforts.

Arms control efforts may therefore solve some of the problems associated with hypersonic missiles, but they would need to be targeted at alleviating the specific issues that both short- and long-range hypersonic weapons raise. For example, traditional limits on the number of missiles a country can have are unlikely to solve strategic stability problems for two reasons. First, because the estimated costs of each missile are so high that countries are not likely to invest in significant numbers of them and thus acquisition is probably self-limiting. Second, because the missiles are most useful (and most dangerous) in a first-strike scenario that takes out other existing air defenses and paves the way for sub-sonic missiles and non-stealth aircraft. Thus, countries do not need significant numbers of hypersonic missiles in order to use them effectively and still undermine strategic stability, making numerical limits on missiles and warheads less useful than other measures.

By contrast, arms control agreements that differentiate between missiles based on range may have

84 Stephen M. Walt, *The Origins of Alliances* (Ithaca, NY: Cornell University Press, 1990); and Morrow, “Alliances.”

85 Gilpin, *War and Change in World Politics*.

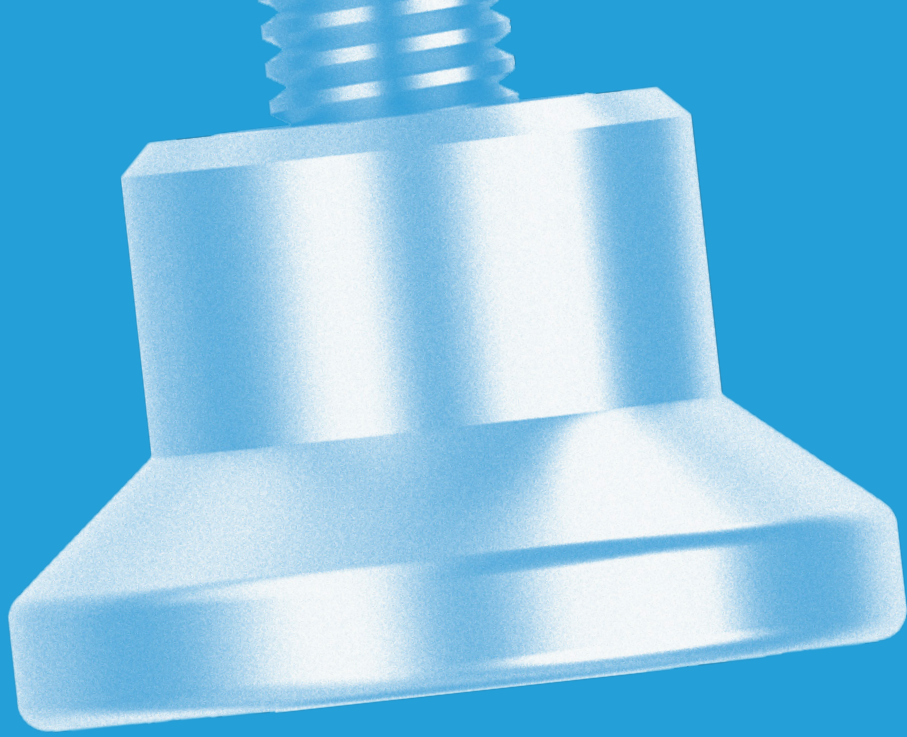
86 Schelling and Halperin, *Strategy and Arms Control*.

87 The term “democratizing technology” most often refers to technologies that are thought to spread information to mass numbers of people and encourage demands for government accountability and other democratic political movements. See, for example, Tyler J. Veak, ed., *Democratizing Technology: Andrew Feenberg's Critical Theory of Technology* (Albany, NY: State University of New York Press, 2006). However, it may also be used to refer to technology that reduces inequalities in power between states.

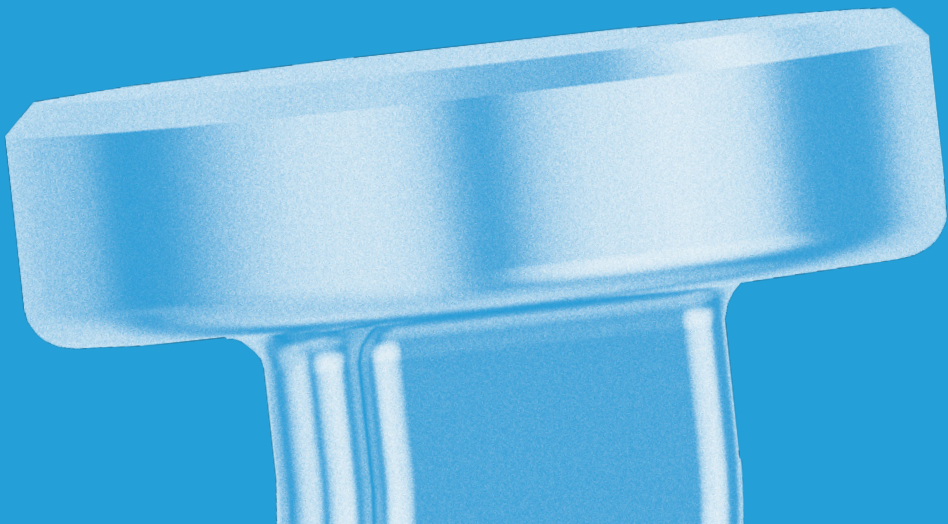
88 Joseph S. Nye, Jr., “NPT: The Logic of Inequality,” *Foreign Policy* no. 59 (Summer 1985): 123–31, <https://doi.org/10.2307/1148604>.

89 See, for example, Andrea Gilli and Mauro Gilli, “Why China Has Not Caught Up Yet: Military-Technological Superiority and the Limits of Imitation, Reverse Engineering, and Cyber Espionage,” *International Security* 43, no. 3 (Winter 2018/2019): 141–89, https://doi.org/10.1162/isec_a_00337.

90 Brett V. Benson, *Constructing International Security: Alliances, Deterrence, and Moral Hazard* (Cambridge, MA: Cambridge University Press, 2012).



Where arms
control may be
useful and feasible
is in limiting
attempts to create
defenses against
such weapons.



a more important effect. Indeed, efforts to ban or severely limit short-range hypersonic missiles, while allowing for the development of longer-range hypersonic capabilities, may have the dual effect of encouraging strategic stability by guaranteeing second-strike capabilities while reducing offensive incentives at the regional level. Agreements that focus exclusively on long-range hypersonic systems may actually undermine stability and cause more problems than they would solve. At a more basic level, even simple agreements to reject dual-warhead models and monitor and verify nuclear or conventional capabilities would significantly reduce warhead ambiguity and lessen pressure on states to make worst-case assumptions. Realistically, however, Russia and China have little incentive to agree to such an agreement, given that their hypersonic programs are, in large part, motivated by concerns over U.S. missile defense systems.

Finally, nonproliferation efforts that focus on preventing the spread of hypersonic technology to regional powers may be particularly effective in preventing regional rivalries from escalating and undermining regional stability. Given that short-range hypersonic weapons are likely to be most destabilizing, limiting the spread of the technology as long as possible to regional rivals — including through export bans — may go a long way toward keeping the speed of conflict down.

Domestic Influences on Arms Control

Leaders making decisions about arms control and nonproliferation agendas must also consider how such efforts will be interpreted and supported by their electorates (or, in the case of autocracies, their selectorates).⁹¹ One of the principle goals of arms control agreements is to prevent arms races by placing limits and caps on the number of new weapons and delivery systems a state is able to build. When new technologies require numerical superiority (such as the number of nuclear warheads a state possesses), there are strong incentives for a state to continue acquiring and building

more weapons as its adversary does the same. This can have profound effects on a state's finances and ability to fund other public goods that are critical to a state's strength and health. Arms control agreements, by eliminating arms races, therefore allow states to redistribute resources to other priorities and public goods such as healthcare, education, and infrastructure.⁹² It is commonly asserted that one of the primary causes of the collapse of the Soviet Union was the large percentage of GDP it was forced to spend on defense to the exclusion of other public goods.⁹³ Controlling the cost of defense and weapons acquisitions, therefore, is a critical balancing act that leaders must negotiate. Even rich countries, when facing difficult economic conditions, may find arms control agreements to be a valuable tool for ensuring fiscal health.⁹⁴ Overall, arms control agreements can both alleviate fiscal pressure and allow politicians to fund domestic priorities that their constituents favor.

Leaders must also balance public attitudes toward international competition and conflict when making decisions about arms control. Countries with memories of war and conflict that prioritize a narrative of suffering and loss may be more anxious about future wars than countries whose memories of war involve less sacrifice.⁹⁵ This can translate into differences in foreign policy preferences, with historical memory playing an important part in a country's willingness to risk an arms race instead of supporting an arms control initiative. These attitudes can also change over time and in response to discrete events and new technologies. For example, while Americans were, on the whole, uninterested in going to war against the Axis powers throughout 1941, the attack on Pearl Harbor mobilized public opinion to support the war regardless of cost. By contrast, the existential dread that accompanied the Cuban Missile Crisis, combined with the explosion of China's first nuclear weapon less than two years later, led many Americans to support early arms control agreements, even those who had previously expressed faith in America's ability to defeat the Soviet Union in a conflict.⁹⁶ It follows then

91 For a thorough review on the impact of domestic politics on policymakers' choices on nuclear matters, see Elizabeth N. Saunders, "The Domestic Politics of Nuclear Choices—A Review Essay," *International Security* 44, no. 2 (Fall 2019): 146–84, https://doi.org/10.1162/isec_a_00361. For a review of selectorate theory, see Randolph Siverson and Bruce Bueno de Mesquita, "The Selectorate Theory and International Politics," in *Oxford Research Encyclopedia of Politics*, ed. William R. Thompson (Oxford: Oxford University Press, 2017).

92 Bernard Brodie, "On the Objectives of Arms Control," *International Security* 1, no. 1 (Summer 1976): 17–36, <https://doi.org/10.2307/2538574>.

93 See, for example, Fred Chernoff, "Ending the Cold War: The Soviet Retreat and the U.S. Military Buildup," *International Affairs* 67, no. 1 (January 1991): 111–26, <https://doi.org/10.2307/2621222>.

94 Brodie, "On the Objectives of Arms Control."

95 David A. Messenger, *War and Public Memory: Case Studies in Twentieth-Century Europe* (Tuscaloosa: University of Alabama Press, 2020).

96 See, for example, remarks by President John F. Kennedy about his presidency. "JFK on Nuclear Weapons and Non-Proliferation," Carnegie Endowment for International Peace, Nov. 17, 2003, <https://carnegieendowment.org/2003/11/17/jfk-on-nuclear-weapons-and-non-proliferation-pub-14652>.

that public attitudes can be a decisive factor in a leader's decision to pursue arms control.

While studies of public opinion most often involve democracies and the incentives presented to democratic leaders, autocratic leaders must also satisfy powerful elites, who may have interests that diverge from national priorities.⁹⁷ Domestic politics in autocracies, therefore, may shape a leader's willingness to engage in arms control initiatives based upon who gains and loses from the military industry and military production. New technologies present substantial economic opportunities for elites who own defense contracting firms, leading them to pressure a leader to continue production and reject nonproliferation efforts. By contrast, a leader looking to isolate a powerful defense elite might pursue or engage in arms control talks to punish political rivals, independent of strategic calculations.⁹⁸

Most of the hype about hypersonic weapons has revolved around the question of whether the introduction of hypersonic glide vehicles will start a new arms race — an international security dilemma that can have significant domestic effects.⁹⁹ Concerns about a hypersonic missile gap, reminiscent of discussions about nuclear weapons in the Cold War, have informed much of the public reporting and general concern that has prompted many to call for arms control. However, there are two issues that challenge the feasibility of arms control. The first is that it is unclear whether having a numerical superiority of hypersonic weapons is a strategic advantage. Indeed, there have been two major reasons listed for acquiring hypersonic weapons: They are able to penetrate air defense systems so that other weapons platforms can function properly, and they are able to strike hardened or isolated targets (nuclear sites or terrorist hide outs, for example) with little or no warning. Neither of these scenarios require large numbers of missiles. As a result, placing limits on the number of hypersonic missiles that great powers can possess is unlikely to solve the real problems that hypersonic weapons generate.

Second, there is little appetite among either the American public or America's adversaries for an

arms control agreement. Whereas an international event like the Cuban Missile Crisis sufficiently frightened Americans in the 1960s over the prospect of nuclear war, Americans today appear to be much more skeptical of arms control agreements that seek to limit offensive capabilities. The technical difficulties, combined with the prevailing public mood, make an arms control agreement unlikely.

Where arms control may be useful and feasible is in limiting attempts to create defenses against such weapons. For decades, the Anti-Ballistic Missile Treaty rested upon what Thomas Schelling termed, "mutual vulnerability." Stopping states from developing defenses against strategic ballistic missiles would prevent the inevitable arms race that comes from developing a weapons system, finding a defense against that system, and developing a more advanced, lethal, and expensive system that can evade such defenses.¹⁰⁰ This cycle can prove exceptionally costly. It is widely recognized that research is already underway to develop active defenses against hypersonic glide vehicles and the kind of stealth technology that has been embedded into fifth-generation weapons systems in the United States.¹⁰¹ Indeed, some are already suggesting that arms control efforts should focus not on the hypersonic missiles themselves but on the root cause of the missiles — U.S. advancements in missile defense. A new anti-ballistic missile treaty, one that ensures all states have the ability to retaliate effectively against aggression, may reduce the pressure to develop inter-continental hypersonic weapons in the first place and halt at least one part of the emerging arms race.

This type of agreement, however, would need to address the growing number of operational hypersonic missiles already in Russian and Chinese arsenals. These demands would come at a moment when American support for arms control has been declining as domestic polarization increases and the focus has shifted to threats from China. Indeed, arms control agreements that do not include China are considered a non-starter for many powerful domestic actors in the United States today, as well as many within the military.¹⁰² As a result, America has withdrawn from the Intermediate

97 Bruce Bueno de Mesquita, et al., *The Logic of Political Survival* (Cambridge, MA: MIT Press, 2003).

98 David Dawkins, "Putin vs. the Oligarchs: Russia Is Fighting a \$50 Billion Payout in a U.S. Court," *Forbes*, June 19, 2020, <https://www.forbes.com/sites/daviddawkins/2020/06/19/putin-vs-the-oligarchs-russia-is-fighting-a-50-billion-payout-in-us-court/#137621691691>.

99 Smith, "Hypersonic Missiles Are Unstoppable."

100 Schelling, *Arms and Influence*; and Charles L. Glaser, *Analyzing Strategic Nuclear Policy* (Princeton, NJ: Princeton University Press, 1990).

101 Venable and Abercrombie, "Muting the Hype Over Hypersonics"; and "Russia Touts S-500's Ability to Destroy Hypersonic Weapons in Space," *Moscow Times*, July 3, 2020, <https://www.themoscowtimes.com/2020/07/03/russia-touts-s-500s-ability-to-destroy-hypersonic-weapons-in-space-a70767z>.

102 Robbie Gramer and Jackie Detsch, "Trump Fixates on China as Nuclear Arms Pact Nears Expiration," *Foreign Policy*, April 29, 2020, <https://foreignpolicy.com/2020/04/29/trump-china-new-start-nuclear-arms-pact-expiration/>.

Range Nuclear Forces (INF) Treaty, the Open Skies Treaty, and the Joint Comprehensive Plan of Action (otherwise known as the Iran nuclear deal). There has also been discussion about resuming nuclear testing in violation of existing international laws and norms.¹⁰³ Further, the United States came perilously close to allowing the New START bilateral nuclear arms control agreement expire, which would have left the United States without a way to monitor Russian nuclear forces for the first time in 50 years. As polarization continues to divide America, this pattern looks unlikely to change, and will almost certainly impede any effort to ratify a formal treaty in the Senate, where 67 yeas are needed.¹⁰⁴

Estimating the Costs of Arms Control

Finally, arms control agreements can also come with costs to domestic innovation, commerce, and international politics. First, nonproliferation efforts almost always involve shutting allies out of markets for new technologies or limiting the conditions under which they can receive the military benefits of such technologies.¹⁰⁵ This can both create problems for alliance relations and have consequences for the balance of power. The proliferation of technology to allies can have useful advantages for gaining leverage over strategic rivals. For example, the United States was able to trade the removal of intermediate missiles stationed in NATO ally Turkey in exchange for a resolution to the Cuban Missile Crisis. But when allies are prevented from acquiring certain types of technology, they both become more dependent upon the great power for security and less helpful when their allies need external support.

Arms control and nonproliferation efforts can also significantly impact commerce and the private sector. Because so many technologies are “dual use” — can be used for both military and commercial purposes — arms control agreements must carefully balance the benefits of limiting proliferation against the potential benefits a technology may have for human welfare, economic gain,

and international cooperation. This was a difficult balance to strike in the 1960s when states were debating the Nuclear Nonproliferation Treaty, because the potential benefits of peaceful nuclear energy were expected to be significant.¹⁰⁶ Similarly, the emergence of the internet has created an entirely new domain for warfare and led to significant vulnerabilities. But it has also powered a new information age and unprecedented world-wide economic growth.

Finally, leaders should evaluate the costs of monitoring associated with nonproliferation initiatives and arms control agreements. Surveillance and intelligence collection can be expensive and time-consuming. In a world where resources are finite, states have to make hard choices about what they can and cannot reasonably monitor. Similarly, if the technology in question is such that cheating is easy both to do and hide, then the costs associated with an arms control agreement (especially for a state that intends to comply in good faith) may not be worth the expected benefits. As former President Ronald Reagan explained when describing his own arms control agreements with the Soviet Union, one must “trust, but verify.”¹⁰⁷ When the costs of verification outweigh the strategic and domestic benefits of the arms control agreement itself, however, leaders should reevaluate their commitment to the agreement.

Costs associated with arms control agreements about hypersonic weapons are unlikely to be significant. For all three of the costs discussed above — allied relations, commercial technology, and monitoring — there appear to be relatively few obstacles that would prevent great powers from engaging in arms control or nonproliferation measures for hypersonic weapons. Indeed, while some European allies like France are actively engaged in their own hypersonic missile research, most of America’s European allies have expressed little interest in acquiring hypersonic technology unless used for commercial purposes, particularly for space.¹⁰⁸ Further, limiting the spread of technology greatly favors certain vulnerable U.S. allies such as Israel and South Korea, who rely heavily on missile

103 Eryn MacDonald, “Is the United States Planning to Resume Nuclear Testing?” Union of Concerned Scientists, July 1, 2020, <https://allthingsnuclear.org/emacdonald/is-the-united-states-planning-to-resume-nuclear-testing/>.

104 Carrie A. Lee, “Electoral Politics, Party Polarization, and Arms Control: New START in Historical Perspective,” *Orbis* 63, no. 4 (2019): 545–64, <https://doi.org/10.1016/j.orbis.2019.08.007>.

105 See, for example, James A. Thomson, *The Arms Control Challenge to the Alliance*, RAND Corporation, 1987, <https://www.rand.org/pubs/papers/P7382.html>.

106 Dwight D. Eisenhower, “Atoms for Peace Speech,” Address to the 470th Plenary Meeting of the United Nations General Assembly, Dec. 8, 1953, available online at the International Atomic Energy Agency, accessed Aug. 30, 2022, <https://www.iaea.org/about/history/atoms-for-peace-speech>.

107 Thom Shanker, “Battle Turns Gentle with Proverbs Galore,” *Chicago Tribune*, Dec. 9, 1987, <https://www.chicagotribune.com/news/ct-xpm-1987-12-09-8704010440-story.html>.

108 Speier et al., *Hypersonic Missile Nonproliferation*.

defense systems for security and would be highly threatened should Iran or North Korea acquire hypersonic missile technology.¹⁰⁹

The commercial prospects for hypersonic technology is also limited. While there has been some exploration of using hypersonic missile technology to increase the cost-effectiveness of commercial space operations in the European Union, and some discussion about the potential for hypersonic commercial travel in Asia and Australia, the feasibility of such ventures are still significantly far off.¹¹⁰ It is unclear, and perhaps even unlikely, that such ventures would be either profitable or sustainable, and thus worth the potential risks of an unregulated open market for hypersonic technology.¹¹¹

Finally, some work has already been done to envision what a hypersonic nonproliferation treaty might look like, and how it could be folded into existing nonproliferation regimes. The properties of hypersonic technology, such as its unique requirements for specialty materials and the need for testing and testing facilities, mean that cheating on such a regime could be easily detectable. This would enable successful monitoring efforts.¹¹²

Conclusions and Implications for U.S. Policy

The emergence of hypersonic weapons has led to a series of robust debates about the degree to which the United States should pursue their development and acquisition, as well as how seriously the United States should push for an arms control regime. This paper has sought to walk through the general criteria that policymakers should use when developing any new technology, and has applied this logic to the expected capabilities and advantages provided by hypersonic missiles. It has also found that short- and medium-range hypersonic weapons are most useful to states that have revisionist agendas and may employ *fait accompli* strategies to quickly and efficiently grab territory. However, they are less useful from a defensive posture.

When evaluated according to these criteria, U.S. policy on developing and acquiring hypersonic weapons appears to over-state the importance of introducing them into its arsenal. Far from being a necessary acquisition in a new arms race,

hypersonic weapons appear to be primarily useful to the aggressive and the disadvantaged — two things that the United States is not. The costs associated with the development of conventional hypersonic weapons are high enough — both fiscally and strategically — that the United States should pause and think carefully about whether the aggressive pursuit of these weapons is indeed in the national interest.

By contrast, American investments in hypersonic missile defense, particularly at short and medium range, could reap significant dividends. Better defense against hypersonic missiles would both signal to adversaries and the international community that the United States was not interested in aggressive action, but rather just concerned about defending existing territory. It would reduce the incentives for other countries to invest in procuring additional hypersonic weapons, and it would deter them from using them in the event of a conflict with the United States. When limited to short and medium range, better hypersonic missile defense significantly reduces the first-mover advantages associated with hypersonic missiles today.

This framework suggests that U.S. efforts at arms control should be revisited as well, particularly with regard to the proliferation of hypersonic technology and missile exports. America's existing strategic ballistic missile defense is most effective against small numbers of ballistic missiles from countries that it considers "rogue regimes," such as North Korea. The proliferation of hypersonic glide vehicle technology to these states could significantly undermine U.S. homeland defense, making America vulnerable to a strategic attack from an unstable regime. Further, the proliferation of hypersonic technology to regional rivals could significantly exacerbate conflict and instability across the globe. The United States should therefore push aggressively to limit the spread of hypersonic missile technology in a significant way.


Overall, this paper has sought to take a step back. It first provided a framework, using existing theory, to structure debates about the acquisition of new technologies and arms control. It then evaluated how hypersonic weapons and hypersonic technology more broadly fit into these debates — highlighting areas for future research and the weapons' potential policy implications. Hypersonic weapons undoubtedly raise important questions

109 Maya Margit, "Hypersonic Weapons, Drones Mark Top Challenges for Israeli Missile Defense Experts," *The Media Line*, Dec. 5, 2019, <https://themedialine.org/by-region/hypersonic-weapons-drones-mark-top-challenges-for-israeli-missile-defense-experts/>.

110 Speier et al., *Hypersonic Missile Nonproliferation*.

111 Speier et al., *Hypersonic Missile Nonproliferation*.

112 Speier et al., *Hypersonic Missile Nonproliferation*.

about the future of strategic stability and deterrence in today's environment. All three major powers are already either employing these weapons in conflict or preparing to introduce them into their arsenal quickly, meaning that the international system will be faced with the very dilemmas and decisions outlined above in the very near future. Understanding how missile delivery, speed, and technological change impact decision-making and strategic thought at the highest level is therefore of paramount importance in an increasingly challenging international environment. 

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