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Strategic Implications Caused by Hypersonic Strike Weapons

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STRATEGIC IMPLICATIONS CAUSED BY HYPERSONIC STRIKE WEAPONS

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ABSTRACT

Emerging technology is having a substantial impact on strategic stability. This thesis will analyze the impact of developing hypersonic weapon systems globally on strategic stability. Hypersonic weapons are defined as weapons that travel at least five times the speed of sound (Mach 5). Hypersonic Strike Weapons (HSW) are hypersonic weapons capable of maneuvering at hypersonic speeds that makes them much more difficult to engage when traveling at such high speeds. They are a relatively new technology that is currently being pursued by multiple nations throughout the world.

The United States is currently the only country that has officially declared all hypersonic strike weapons will remain conventional, with adversary nations suggesting that they are arming hypersonic strike weapons with nuclear warheads. If other nations arm their hypersonic weapons with nuclear warheads, a decapitating strike becomes a serious threat that has to be considered when developing defensive strategies. This could lead to a decrease in strategic stability around the globe as more nations become fearful of others first strike capabilities. This could cause nations to have their nuclear response on a much shorter tether, bringing back situations that have not been seen since before the end of the cold war.

As hypersonic weapons become operational, national defense strategies will have to adapt to the emerging threats to nations around the globe. Without a proper response an increase in risk and a decrease in strategic stability could occur.

This thesis looks at what hypersonic weapons are, what nations are looking at developing them, what purpose they may hold in a nation's strategic arsenal, what strategic instabilities are caused by the development and operationalization of hypersonic weapons and the rhetoric that follows along with them. The paper concludes with some thoughts on possible ways to limit the instabilities caused by hypersonic weapons and its impact on strategic stability and U.S. defense policy.

KEYWORDS: Hypersonic Strike Weapon, Hypersonic Glide Vehicle, Strategic Deterrence, Instability, Emerging Technology, Defense Strategies, First Strike

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In the interest of academic freedom and the principle of free speech, approval of this thesis indicates the format is acceptable and meets the academic criteria for the discipline as determined by the faculty that constitute the thesis committee. The content and views expressed in this thesis are those of the student-scholar and are not endorsed by Missouri State University, its Graduate College, or its employees.

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Introduction

While not "strategic" in the same manner as nuclear weapons, advanced dual-capable technologies created out of long-term technological improvements and advancements, such as hypersonic weapons, hold the potential to render strategic effect by complicating the survivability of strategic forces. Strategic effects are usually thought of as war winning effects that disrupt an adversary's strategy. Strategic forces are seen as forces capable of achieving a strategic effect and are usually seen as a nuclear power's nuclear forces. These trends have consequently challenged the strength of nuclear deterrence and increased the complexity of maintaining strategic stability among the world's major nuclear powers, the United States, Russia, and China.[1]

As conventional weapons technology continues to advance, there will exist a subset of weapons that are clearly conventional but of such a strategic magnitude so as to elicit a possible a nuclear response. Hypersonic weapons have the capacity to be one of those weapons and may pose a significant threat to the current strategic balance of power and operations of great power nations to include the United States, Russia, and China.[2]

[1] Madison Estes et al, "New Futures for Nuclear Arms Control: Examining a Framework and Possibilities with Hypersonic Weapons," *Center for Strategic and International Studies,* (2022): 24, http://www.jstor.org/stable/resrep24234.6.
[2] Kyle Yohoe et al, "An Offensive Leap: An Analogy of Hypersonic Weapons to Early ICBMs," *Center for Strategic and International Studies,* (2022): 97, http://www.jstor.org/stable/resrep24234.12.

The development of hypersonic weapons may pose a challenge to strategic missile defenses and raise wider international security concerns due to their potential to further complicate strategic relations, encourage new arms competition and endanger stability.[3]

The military advantage of hypersonic delivery systems lies in their ability to strike promptly over long distances while evading early-warning radars and ballistic missile defenses – but some advocates of the technology contend that hypersonic strike weapons (HSWs) could be utilized in lieu of nuclear weapons in some roles. HSWs are seen by many to be destabilizing. They could be utilized in attacks against nuclear and other strategic military assets, could possibly be mistaken for ballistic missiles, and could even be equipped with nuclear warheads.[4]

According to Bernard Brodie, there is nothing automatic about the influence of weaponry on warfare. That influence has to be exerted initially through the minds of men, who make judgments, first, about the utility of weaponry or other devices and, second, about the tactical and strategic implications of the general adoption of these new weapons or devices.[5] Although HSWs may represent a revolution in military technology, that in itself will not cause a shakeup in strategic stability. An increase or decrease in stability will be dependent on how these new weapons are implemented and how other nations perceive the implementation of these weapons by their adversaries.

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[3] Maya Brehm and Anna de Courcy Wheeler, "Hypersonic Weapons Discussion Paper for the Convention on Certain Conventional Weapons (CCW)," *Article 36*, February 2019. https://article36.org/wp-content/uploads/2020/12/hypersonic-weapons.pdf.
[4] Tong Zhao, "Going Too Fast: Time to Ban Hypersonic Missile Tests?" *Bulletin of the Atomic Scientists* 71, no 5. (September 2015): 5. doi:10.1177/0096340215599774.
[5] Jacquelyn Davis, "Technology and Strategy: Lessons and Issues for the 1990s," *The Annals of the American Academy of Political and Social Science* 517 (1991): 209-210. http://www.jstor.org/stable/1047196.

Technology That Impacted Strategic Stability

Technology has always been an integral part of achieving military superiority. The following chapter will introduce a few significant examples of military technologies throughout history that have had an impact on the state of stability at the time. This grouping of items is merely a representation of how changes in technology can cause stability issues and by no means is meant to be all inclusive.

A stone axe or wooden club gave a Neolithic fighter a major advantage over an unarmed opponent. As weapons have evolved from bows and arrows to intercontinental ballistic missiles, militaries continuously have sought to harness new technologies to gain an edge on adversaries. Technology alone rarely conveys a decisive advantage, but technology is an enabler for military superiority. When combined with the right organization, training and concepts for warfighting, technological advantages can make battles hopelessly one-sided affairs.[6]

Across the centuries, new technologies have periodically altered the character of war in dramatic fashion, a process often referred to as a *military revolution* or a *revolution in military affairs.* While historians long have studied the impact of emerging technology on war, policy-oriented study of military revolutions has a more recent origin.[7] Below are only a few examples of technologies that altered warfighting capabilities and therefore stability in their time. They will range from ancient with the chariot, to medieval with the crossbow, following up with the

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[6] Paul Scharre and Ainikki Riikonen, "Introduction," *Defense Technology Strategy,* New America (2020): 4. http://www.jstor.org/stable/resrep26976.3.

[7] John Maurer, "The Future of Precision-Strike Warfare: Strategic Dynamics of Mature Military Revolutions," *Naval War College Review* 76 no.2 (2023): 14. https://www.jstor.org/stable/48735672.

modern era of the airplane, missile defenses, nuclear weapons etc. As the below technologies altered stability in their time, HSWs may alter strategic stability in the years to come.

Chariot

Chariots were perhaps the most dominant instrument of warfare before nuclear weapons. Historian William H. McNeill has called them the superweapon of their day. When they appeared in the Levant in the eighteenth-century Before the Common Era (BCE), they swept all before them. From Egypt to Mesopotamia, states either adopted chariots or ceased to compete in interstate war. The chariot craze bred an international chariot aristocracy, the Maryannu, who sold their services to the highest bidder.[8] States built up enormous chariots' corps with attendant supply and maintenance trains, culminating in the battle of Kadesh in 1275 BCE, when the contending Egyptian and Hittite forces committed an estimated 5,000 chariots to a cataclysmic but ultimately indecisive day of battle. Western warfare through most of the second millennium BCE was chariot warfare. The chariot defined, drove, governed, circumscribed ground warfare.[9] And then it was gone. It is possible that the introduction of iron weapons around 1200 BCE gave infantry new power to stand up to chariots. Another possibility is infantry tactics coupled with iron weapons was the cause. Whatever the cause, the apparent determinism of the chariot evaporated.[10]

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[8] Arthur, Cotterell "Chariot: The Astounding Rise and Fall of the World's First War Machine," (London: Pillico, 2004), 67-68.

[9]Alex Roland, "War and Technology," *Foreign Policy Institute,* (February 27, 2009): https://www.fpri.org/article/2009/02/war-and-technology/.

[10] Roland "War and Technology."

Crossbow

The crossbow played a pivotal role in reshaping the landscape of warfare. It represented a significant technological leap in projectile weaponry. Its key innovation lay in the horizontal bow mounted on a stock, enabling soldiers to release powerful shots with greater accuracy and force than traditional bows. This technological advantage allowed for the effective deployment of projectiles over longer distances, transforming the nature of ranged combat. The crossbow's impact provided armies with a versatile and potent ranged weapon that could pierce armor and penetrate shields, making it a formidable force on the battlefield. Crossbowman could be quickly trained and deployed, providing armies with a more flexible and responsive ranged component. The ability to rain down a barrage of projectiles from a distance disrupted traditional melee formations, challenging the dominance of heavily armored infantry.

The crossbow's impact on warfare was transformative, altering the dynamics of battles and sieges. Its technological advancements, tactical implications, and social consequences marked a significant chapter in the history of military innovation, playing a crucial role in shaping the nature of conflict during the medieval period and beyond.

Firearm

The introduction of firearms revolutionized military tactics. Traditional warfare dominated by close-quarters combat and hand-to-hand skirmishes, was turned upside down. Firearms (muskets and early rifles) allowed soldiers to engage the enemy from a distance, fundamentally changing the dynamics of battlefields.[11] The increased range and power of firearms challenged the effectiveness of traditional armor, rendering medieval knights and heavily armored infantry vulnerable. Cannons and artillery became instrumental in breaching fortifications, marking the decline of impregnable castles. The ability to launch projectiles over long distances shifted the balance of power in favor of besieging forces, altering the strategies employed in laying siege to fortified cities. The age of gunpowder and firearms heralded a new era, laying the foundation for the modern military landscape and forever changing the dynamics of warfare.

Airplane

One of the initial fundamental impacts of the airplane on warfare was in the realm of reconnaissance. Before the airplane, military forces relied on ground-based scouts and limited visual observation to gather intelligence about enemy locations and movements. The airplane's ability to quickly cover large areas and provide an aerial perspective revolutionized reconnaissance. Armies could now survey enemy positions, troop movements, and terrain more comprehensively, offering commanders real-time information for strategic decision making. Italian General Giulio Douhet was an initial proponent of air power. In 1911 when Italy went to war against the Ottoman Empire for control of Libya, aircraft operated for the first time in reconnaissance, transport, artillery spotting and limited bombing roles. Douhet wrote a report on the aviation lessons learned in which he suggested high altitude bombing should be

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[11] Larry Evans, "The Evolution of Firearms: A Historical Perspective", accessed December 14, 2023, https://littlefeatherleather.com/The-Evolution-of-Firearms/.

the primary role of aircraft. At the start of World War I, Douhet called for Italy to launch a massive military build-up of aircraft in order to gain command of the air and render an enemy "harmless".[12]

As technology advanced, fighter planes emerged, leading to the concept of air superiority. Control of the skies became a critical factor in military success. The ability to conduct aerial dogfights and engage in strategic bombing raids shifted the balance of power.

The advent of strategic bombing brought about a seismic shift in military tactics. Airplanes enabled the delivery of bombs deep into enemy territory, targeting infrastructure, industrial centers, and civilian populations. The ability to strike beyond the front lines altered the nature of warfare, blurring the distinction between the battlefield and the home front. The exploitation of air power by the time of World War II further contributed to bringing the war to the home front. The ability to directly target enemy homelands and military-industrial infrastructure illustrates another concept that can be attributed to the evolution of technology, namely the need to rely on larger political groupings, alliance coalitions – to attain strategic objectives and to defend national interests.[13] Strategic bombing campaigns had far-reaching consequences, influencing both military and civilian morale, paving the way for the concept of total war.

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[12] Philip S. Meilinger, "Giulio Douhet and the Origins of Airpower Theory," *The Paths of Heaven: The Evolution of Airpower Theory,* ed. Philip S. Meilinger (New Delhi, India: Lancer Publishers. 2002), 3.
[13] Davis, "Technology," 211.

Nuclear Weapon

By far the most dramatic example of the late-twentieth-century relationship between strategy and technology lies in the nuclear sphere, with the development of the atomic bomb and the fusion-fission hydrogen bomb device. Among the possessors of nuclear weapons, war deterrence has become priority in national security planning. According to the 2022 United States National Defense Strategy, although defending the homeland is a priority, two other main priorities include deterring strategic aggression and attacks against the United States, Allies and partners and being prepared to prevail in a conflict if deterrence were to fail.[14] Nuclear weapons are a large part of this deterrent.

In the traditional struggle between offense and defense in strategic thought, the development of nuclear weapons and long range nuclear missile launchers carrying highly accurate warheads pushed the balance toward the offense and such concepts strategic surprise, preemption and first strike attacks.[15] Proportional deterrence theory asserts that deterrent forces must be scaled to inflict costs on an adversary that exceed the potential gains involved in either a large-scale nuclear attack or a conventional invasion. The key to the proportional-deterrence strategy is the perceived ability of a smaller power to inflict widespread destruction against an opponent's infrastructure – industry – and cities, known as counter value targeting, even though the opponent may deploy numerically greater and perhaps qualitatively superior nuclear weapons of its own.[16]

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[14] U.S. Department of Defense, *National Defense Strategy,* Washington, DC: DOD, October 2022. https://apps.dtic.mil/sti/trecms/pdf/AD1183514.pdf.
[15] Davis, "Technology," 211-212.
[16] Davis, "Technology," 212.

The above discussed strategy led to the development of mutual assured destruction (MAD) thinking in the United States. MAD posits that a full-scale use of nuclear weapons by one nuclear armed state on another that maintained a second-strike capability would cause the complete annihilation of both the attacker and the defender. Assuming that both nations are rational actors, the threat of utilization of strong weapons against the adversary with an assured second strike capability prevents them from utilizing those same weapons initially.

Many technological changes are evolutionary improvements in technology that only catalyze evolutions in strategic thinking. In the case of nuclear weapons, the improvement was so radical that the new technology revolutionized how nations thought about war.[17] As Thomas Schelling explained, prior to the advent of nuclear weapons, only the loser was punished – and then, only after it lost. Nuclear weapons could destroy so much and so quickly, he argued, that annihilation could come to either side at any time during the conflict.[18]

Satellite

The U.S.S.R. launch of Sputnik on October 4, 1957, is an example of deterrence-destabilizing technological advantages. When something like this happens, one side develops a large advantage over the other. The orbiting sphere showcased a first strike nuclear attack capability of the U.S.S.R., upset the perception of a nuclear stalemate, fed the U.S.'s fear of a missile gap and spurred the intercontinental ballistic missile and nuclear arms race.[19] The

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[17] Nathan Terry and Paige Price Cone, "Hypersonic Technology: An Evolution in Nuclear Weapons?, *Strategic Studies Quarterly* 14, no. 2 (2020): 76, https://www.jstor.org/stable/26915278.

[18] Thomas Schelling, *Arms and Influence* (Yale University Press, 2020) 24-27, Terry and Cone, "Hypersonic Technology," 76.

[19] Reny, Stephen. "Nuclear-Armed Hypersonic Weapons and Nuclear Deterrence." *Strategic Studies Quarterly* 14, no. 4 (2020): 49. https://www.jstor.org/stable/26956152.

U.S.S.R.'s perceived capability to obliterate the U.S. with virtual impunity upended the nuclear deterrent environment. This instability was further exacerbated by the limited survivability of a U.S. retaliatory force of long-range bombers which would be susceptible to a preemptive intercontinental ballistic missile (ICBM) strike. The missile gap was a perception that the Soviet Union possessed a much greater number and much more powerful nuclear weapons than the United States. This perception introduced an instability into nuclear deterrence that manifested as an ICBM race.[20]

Ballistic Missile

With the introduction of the ICBM, a nation could hold another nation at great risk of large-scale strategic destruction. The ICBM provided emerging capabilities that could not be matched with a strategic bomber force. An ICBM could be launched on a drastically shortened timeline across great distances. With a heightened offensive focus, the Cold War arms race began with the Soviet Union and the United States building up large arsenals of strategic intercontinental weapons, at one point exceeding 60000 total nuclear weapons. The prevailing strategic thinking of the times were offensively minded – mutual assured destruction, launch on warning, and effective second strike.[21]

The development of the ICBM shifted global strategic powers from an offensive-defensive development cycle to an offensive-offensive cycle. Without effective defensive capabilities, the only method to counter an enemy's offensive ICBM capability was for a nation

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[20] Reny, "Nuclear-Armed" 49.
[21] Yohoe et al, "Offensive Leap," 100.

to develop its own increasingly capable ICBMs. Since the advent of the ICBM, the prevailing global security strategies have focused on displaying or threatening capabilities that incur the greatest costs to the enemy in order to alter decision making. For deterrence to work, nations must have both an assured second-strike capability and the will to use it.[22]

In 1957, Henry Kissinger evaluated the impact of coupling nuclear warheads to missile delivery systems, a relatively new technology at the time. His arguments can be grouped into two criteria. First, technology should be evaluated relative to the advantages provided to one side, particularly in the terms of existing systems. Initially one nation will have an advantage with new technology. When this occurs stability is at its lowest point as the nation may decide to utilize its advantage and strike. Second, eventually technological parity would be reached, and thus technology should be evaluated regarding the implications of both sides possessing the technology.[23] Once this happens more of an equilibrium develops as with the U.S. and the Union of Soviet Socialist Republic (U.S.S.R.) during the cold war. Once both sides had large numbers of nuclear weapons, a triad of ICBMs, submarine launched ballistic missiles (SLBMs), and long range bombers a more stable security environment was obtained as neither nation saw the possibility of achieving a decisive first strike.

Missile Defense System

Antiballistic missile (ABM) systems or ballistic missile defense (BMD) efforts by the U.S. in 1967 caused some instability. Touted to deny an adversary’s advantage to impose cost by

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[22] Yohoe et al, 104.

[23] Henry Kissinger *Nuclear Weapons and Foreign Policy* (New York: Harper Brothers, 1957), 77-78, 120. Terry and Cone, “Hypersonic Technology,” 78.

claiming the capability to intercept inbound nuclear warheads, U.S. BMD programs alarmed the U.S.S.R. In their thinking, a BMD capability violates an adversary's "penetrate enemy active defense" characteristic and diminishes the possibility of ensuring costly retaliation. The U.S.S.R. perceived its missiles to be less likely to provide a credible retaliatory punch against U.S. BMD. This fundamentally undermined the assured vulnerability concept essential to stable nuclear deterrence. This capability-limiting perception spurred the U.S.S.R. to develop its own BMD program, developing a missile defense ring around the capital city of Moscow, pushing both superpowers into a counter BMD arms race. This arms race manifested in the development of multiple independently targetable reentry vehicles (MIRV) capable of defeating BMD systems. The BMD race spurred the MIRV race, which fundamentally was an attempt to return to the nuclear deterrence environment back toward strategic stability between the U.S. and U.S.S.R.[24] In an effort to control these arms races the United States and Soviet Union negotiated the ABM Treaty in 1972. Limiting the amount of defenses to two fixed ground-based defense sites of 100 missiles each. This was later reduced to half the number of permitted defenses in a protocol signed in July 1974.[25]

Henry Kissinger reasoned technology levels are not inherently stable. There is no such thing as equilibrium in terms of technology-based capabilities because parity is a fleeting thing.[26] Major changes in military technology like the development of nuclear weapons altered the way nations viewed weapons and warfare. However, subsequent changes in weapons and

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[24] Reny, "Nuclear-Armed" 51.

[25] "The Anti-Ballistic Missile (ABM) Treaty at a Glance," Arms Control Association, last updated December 2020, https://www.armscontrol.org/factsheets/abmtreaty.

[26] Kissinger, *Nuclear Weapons,* 16-17, Terry and Cone, "Hypersonic Technology," 79.

weapon delivery technology have been evolutionary and have not significantly changed thinking about nuclear deterrence. While each side pursued technological developments to gain some advantages, historical analysis shows that when changes were evolutionary, although there was instability initially, the resulting instability was temporary in nature.[27]

This chapter suggests that a small number of military technological developments can have an effect on the stability between rivals and the nature of warfare. As shown in the previous section, the group that develops a technology first will have an advantage over adversaries until enough time has passed that allows others to develop similar technology, or a new technology that is able to counter the advantage gained and level the playing field. This is particularly visible following the advent of nuclear weapons. The addition of nuclear weapons, first by the United States, followed shortly by the Soviet Union and then other nations, had a profound effect on the way states thought about warfare and defense. The following chapters will discuss hypersonic strike weapons and how their development and implementation may have a similar effect to that of the nuclear weapons discussed above.

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[27] Terry and Cone, "Hypersonic Technology," 79.

What are Hypersonic Strike Weapons

This chapter will define the nature, scope, and features of Hypersonic Strike Weapons (HSWs). This will include the two main types, hypersonic glide vehicles (HGVs) and hypersonic cruise missiles (HCMs) and present the main characteristics of both.

Hypersonic weapons are defined as any weapon that is capable of traveling at hypersonic speeds and must be able to maneuver along its trajectory. Hypersonic is routinely defined as speeds greater than Mach 5 or approximately 3800 mph. HSW capabilities are a combination of speed, range, accuracy, and maneuverability. With these combined capabilities HSWs may be used for global strike, reaching any target within minutes and potentially penetrating defenses with impunity through a combination of tactical surprise (detected later due to lower altitude flight path when compared to a ballistic missile) and maneuverability.[28] HSWs follow a non-ballistic trajectory flying between 18 and 60 miles in altitude. Their maneuverability allows them to change course up to the last minutes of flight and achieve a high degree of targeting precision. The unusual altitude and flight path of hypersonic missiles can result in their being undetectable by existing missile early-warning radars for a majority of their trajectory. Some varieties will be detectable by satellite early-warning systems during their boost-phase, but after that they may disappear from view.[29] Figure 1 shows a comparison of HSW trajectory to a standard Intercontinental Ballistic Missile as related to the earth's atmosphere. This shows the stark difference in achieved altitude between ICBMs, HSGVs and

[28] Reny, "Nuclear-Armed" 49.
[29] Matteo Frigoli, "The Implications of the Advent of Hypersonic Weapon Systems for Strategic Stability," Pugwash Conferences on Science and World Affairs, British Pugwash (December 17, 2019), 1.

HCMs. This difference is one of the main reasons why HSWs are more difficult to detect than ICBMs launched from the same location. The differences between HGVs and HCMs will be discussed in more detail in those sections respectively.

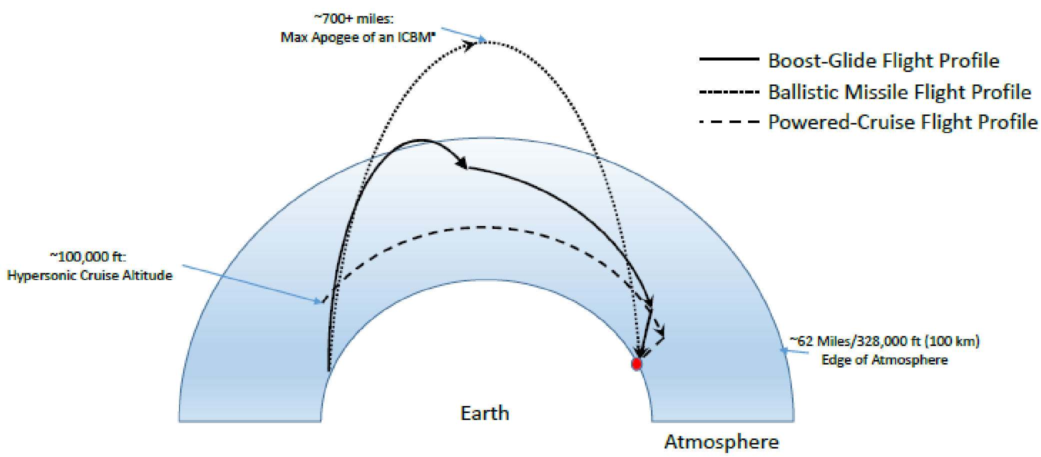

Figure 1. Nominal flight paths of ballistic missiles, hypersonic boost glide vehicles and hypersonic cruise missiles.

As the speed of an object increases to multiples of the speed of sound, multiple engineering problems emerge, especially as the heat generated by the friction of air passing over external surfaces becomes significant. Such 'kinetic heating' can generate substantial heat build-up that needs to be dissipated. At speeds above Mach 5, engineering challenges increase beyond the capacity of relatively straightforward solutions such as the use of titanium and other heat resistant materials rather than the aluminum usually used in aircraft construction. At hypersonic speeds, heat management requires the use of novel materials, and airframe design requires the ability to simulate and test aerodynamic behavior in a regime in which simplifying assumptions about flow behavior that are valid at lower speeds no longer apply. At even higher speeds above Mach 10 and up, the generated heat is sufficient to ionize the surrounding air, creating a high-temperature plasma around the vehicle. Early solutions to these problems consisted of shaping air vehicles to reduce the build-up of heat, the application of ablative materials that would sacrificially burn off or both. Those approaches were used in the first generation of ICBMs, space programs and in the development of manned research aircraft. The first ICBMs, which were the first weapon systems to travel at hypersonic speeds, were deployed operationally by the U. S. and U.S.S.R. in 1959. Later re-entry vehicles employed specialized insulating materials – the well-known ceramic tiles of the space shuttle, for example – instead of ablative coatings for protection.[30]

There are two major types of HSWs that will be discussed in this thesis. They are Hypersonic Glide Vehicles (HGVs) and Hypersonic Cruise Missiles (HCMs). The attributes of both are discussed in greater detail below.

Hypersonic Glide Vehicles

A Hypersonic boost glide vehicle (HGV) is an unpowered vehicle capable of gliding on the upper atmosphere at hypersonic speeds. It is equipped with small propulsion system (Reaction Control System thrusters) for orientation and directional controls. HGVs are mounted on a rocket booster that propels them to the outer atmosphere at speeds greater than Mach 5. After reaching 40-100 kilometers form the earth's surface, the vehicle separates from its booster and is propelled by its momentum, skimming through the thin layers of the upper atmosphere, without following a predictable ballistic trajectory. HGVs make a relatively lower

[30] Andrew Davies, "Coming Ready or Not: Hypersonic Weapons," *Australian Strategic Policy Institute* (2021): 2-3. http://www.jstor.org/stable/resrep31492.

apogee than standard ballistic missiles with a negligible portion of their flight path following a ballistic trajectory (as depicted in Figure 1 on page 14), helping to reduce the susceptibility to an adversary's radar detection.[31]

HGVs are characterized by their speed, range, and maneuverability, with direct tradeoffs among all three performance parameters. Once the booster rocket burns out and falls away, the glide body's only "fuel" is its momentum and altitude which can be traded for speed. The glide body experiences a certain amount of drag, which continuously slows it down along its course. The farther it glides – the greater the range – the slower it will be travelling when it reaches its target. This affects the amount of kinetic energy it has available to produce damage on a target. The second tradeoff is between speed (and range) vs. maneuverability. When a glide body maneuvers it requires more lift than when flying straight and level, this takes energy reducing the velocity of the glide body.[32]

The possible trajectories of an HGV offer some significant operational advantages. An incoming vehicle is less susceptible to detection by ground-based radars early in its flight than a ballistic missile on a high lofted trajectory. Because the radar horizon of an object in flight depends on its altitude, a glide vehicle wouldn't be visible to aerial detection radar systems until it's much closer to the intended target than would be the case for a ballistic missile on a high lofted trajectory. As an example, an ICBM with a typical maximum altitude of around 1500

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[31] Brehm and de Courcy Wheeler, "Hypersonic Weapons Discussion," 2., Frigoli, "Implications," 4., Michael Klare, "An 'Arms Race in Speed': Hypersonic Weapons and the Changing Calculus of Battle," *Arms Control Today* 49, no. 6 (2019): 7. https://www.jstor.org/stable/26755134. Adil Sultan and Itfa Khursheed, "Hypersonic Weapons in south Asia: Implications for Strategic Stability," *IPRI Journal*, (June 30, 2021): https://journal.ipripak.org/wp-content/uploads/2021/07/Article-3-IPRI-Journal-XXI-1.pdf.

[32] Ivan Oelrich, "Cool Your Jets: Some Perspectives on the Hyping of Hypersonic Weapons," *Bulletin of the Atomic Scientists* Vol. 76, no. 1 (2020): 38. DOI: 10.1080/00963402.2019.1701283.

kilometers, is detectable by ground-based radars at around 5000 kilometers distance, while a hypersonic glide weapon at an altitude of 100 kilometers would become visible only in the last 1300 kilometers of its flight, allowing significantly less warning time. HGVs further complicate the surveillance problem relative to ballistic missiles because they have much more capability for maneuver and may approach the target form essentially any direction, making it more difficult to identify the intended target.[33]

One special type of HGV is a fractional orbital bombardment (FOB) system. A FOB system is a payload that is delivered into low-Earth orbit re-entering the atmosphere to attack a target before completing a full orbit. This system has several advantages over traditional ballistic missiles: its range covers the entire Earth; it can execute an attack from any direction; and the time required for a payload delivery can be many minutes shorter than for a comparable ICBM payload.[34] A fractional orbital hypersonic delivery system combines the advantages of a hypersonic glide vehicle with orbital bombardment to create the best of both worlds. A fractional orbital hypersonic bombardment delivery system can deliver payloads up to 10 minutes faster than ICBMs. The trajectories of fractional orbital hypersonic delivery systems are difficult to track, both because they stay closer to the Earth and therefore below the floor of missile defense radars, and because of the increased maneuverability of the hypersonic glide vehicle payload.[35]

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[33] Davies, "Hypersonic Weapons," 5.
[34] Ritwik Gupta, "Orbital Hypersonic Delivery Systems Threaten Strategic Stability," Bulletin of the Atomic Scientists accessed October 26, 2023, https://thebulletin.org/2023/06/orbital-hypersonic-delivery-systems-threaten-strategic-stability/.
[35] Gupta, "Orbital Delivery System."

Hypersonic Cruise Missiles

A Hypersonic Cruise Missile (HCM) is a cruise missile capable of operating at hypersonic speeds. It is equipped with a supersonic combustion ramjet (scramjet) engine which generates thrust from a supersonic airflow. A hypersonic cruise missile can be launched from the ground, a maritime, or an airborne asset and is then boosted to high speeds by a rocket motor. After the scramjet ignites, the missile follows a high-altitude cruise trajectory at a more or less constant speed and altitude. While ballistic missiles spend a relatively short period inside the atmosphere – only during their boost and re-entry phases – hypersonic boost-glide vehicles and cruise missiles spend the bulk of their flight paths within the upper atmosphere, typically at altitudes of between 20 and 60 km.[36] Current subsonic and supersonic cruise missiles are hardly detectable (flying at very low altitude) and follow unpredictable trajectories. HCMs will have these same capabilities and fly at hypersonic speeds capable of posing a complex defensive challenge.[37]

Scramjet technology offers a considerable increase in speed and range of motion, and a sizeable decrease in altitude, which reduces flight times to long distance locations to less than one hour. While comparable to the known flight times of deployed ballistic missiles, hypersonic air-breathing vehicles have the advantage of depressed trajectories, flexible recall, and en-route redirection ideal for stealth delivery of a nuclear or conventional payload.[38]

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[36] Reny, "Nuclear-Armed" 53, Dean Wilkening, "Hypersonic Weapons and Strategic Stability," *Survival* 61, no.5 (2019) 130-131, DOI:10.1080/00396338.2019.1662125.

[37] Frigoli, "Implications," 5.

[38] Rachel Wiener et al, "The Impact of Hypersonic Glide, Boost-Glide, and Air-Breathing Technologies on Nuclear Deterrence," *Project on Nuclear Issues,* Center for Strategic and International Studies (2017): 139. http://www.jstor.org/stable/resrep23162.14.

HCMs can be air-surface- or ship-launched and offer very substantial advantages over their current subsonic or supersonic counterparts. The radically reduced flight time both facilitates the engagement of mobile targets and dramatically reduces the time window available for the defensive detection/tracking/engagement sequence. HCMs cruise at an altitude of 30-50 kilometers which places them beyond the range of most, if not all, existing air defense systems, while in their endgame dive the kinematic problems associated with intercepting a maneuvering missile moving at Mach 5 or greater would be exceedingly difficult to solve with today's technologies.[39] Table 1 compares the characteristics between the main types of HSWs (HGVs and HCMs).

Table 1. Hypersonic Strike Weapon Characteristics.

Characteristics	**HGVs**	**HCMs**
Operating Mechanism	Uses rocket boosters for launch	Uses Scramjet engine
Flight Pattern	Ballistic trajectory before separating from rocket motor	Non-ballistic trajectory
Launch Platform	Land, Sea, Air	Land, Sea, Air
Range	Medium to Long Range	Relatively Shorter than HGV
Altitude	40 to 100 km	< 40 km
Power Supply	Glides toward target	Powered flight throughout
Max Range	Up to 6000 km	1000-3000 km
Speed	Mach 5 – 27	Mach 5 – 10

[39] Ezio Bonsignore, "Hypersonic Weapons: The Reasons Why," *Military Technology* 45 no.1 (2021): 33. https://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=a9h&AN=149206294&site=ehost-live&scope=site.

This chapter described what HSWs are, types of HSWs and the major characteristics of each. The next chapter will provide more detail on why nations may desire to develop and procure HSWs.

Why Develop Hypersonic Strike Weapons

States have many reasons for developing new military technologies. The following chapter provides a discussion on why a state might want to develop HSWs and how they may be utilized. Although this chapter covers many of the possible reasons and uses, there may be other reasons some nations desire HSWs that are not covered here. Some of these reasons may include things like prestige. Like nations attempting to enter the nuclear club, being one of the limited number of nations in the world to have HSWs could come with a certain amount of prestige and respect as seen by others. Another reason may be monetarily. Being able to produce HSWs, a nation could make a large amount of money proliferating the technology to nations and non-state actors that have the desire, but do not have the capability to produce HSWs.

Hypersonic weapons can be utilized to serve multiple strategic goals for states that plan on acquiring them. (1) Hypesonics can be utilized to enhance nuclear deterrence for nuclear states. This is done by guaranteeing that that a state can penetrate an adversaries missile defenses, thus ensuring a second strike capability. (2) Hypersonics aim to increase conventional deep precision strike capabilities in a couple of different ways. This can support an anti-access posture like that of Russia and China, increasing the range and lethality of defenses or be utilized to bypass anti-access areas through a combination of energy and maneuverability as envisioned by the U.S. (3) They are vectors of strategic signaling that can be utilized as an intimidation posture (Russia, China, and North Korea).[40] (4) HSWs could add a destabilizing feature to any deterrent posture, allowing the possibility of a first strike capability. (5) They could also be utilized in a precision strike capability, destroying a high value target without placing a nations forces at risk.

The United States and adversarial operating models are different. China's posture is focused on "counter intervention" by repelling an adversary approaching Chinese waters and operating areas. Its land-based, ballistic and hypersonic weapons are mainly focused on the Chinese mainland or nearby island outposts for this strategy. Contrarily, the U.S. posture is expeditionary. This posture must assume that the majority of pre-positioned, stationary assets will be lost. The U.S. will need an expeditionary hypersonic capability to counter or regain denied access.[41]

Above is a basic discussion regarding why a nation may desire to develop HSWs. The following topics will cover specific reasons nations develop HSWs and then proceed with specific nations that are currently developing HSWs and how they intend to utilize them.

Offense

Parallel to the renewed debates on no first use (NFU) is the advancement and pursuit by the United States of non-nuclear HSWs. These highly maneuverable systems are unique in their ability to traverse unpredictable flight paths at speeds far greater than Mach 5, or five times the

[40] David Pappalardo, "Hypersonics: Between Rhetoric and Reality," *Air and Space Operations Review* 1 no.4 (Winter 2022): 79.
https://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=a9h&AN=161130035&site=ehost-live&scope=site.
[41] David Deptula and William Mahan, "VIEWPOINT: Collaboration Key to Developing Superiority in Hypersonics," *National* Defense 104 n0.788 (2019): 34. https://www.jstor.org/stable/27022646.

speed of sound. With no existing anti-missile system capable of intercepting projectiles maneuvering at such speeds, these weapons have the potential to provide the United States with the ability to hold hostage strategic targets thousands of miles away and execute a devastating conventional attack within minutes.[42]

Compared to maneuverable subsonic cruise missiles and non-maneuvering ballistic missiles with reentry vehicles, the capabilities of hypersonic missiles will improve the ability to elude detection and tracking sensors, penetrate an opponent's air and missile defenses and strike their deep inland targets. As a result, hypersonic missiles could strike targets with little warning and catch an opponent off guard.[43] While sitting as Vice Chairman of the Joint Chiefs of Staff (and former Commander United States Strategic Command) General John Hyten stated that conventional hypersonic missiles could "provide responsive, long range, strike options against distant, defended, and/or time critical threats when other forces are unavailable, denied access, or not preferred. While conventional hypersonic weapons are not a replacement for nuclear weapons, their unique attributes will increase traditional warfighting advantages and bolster conventional and strategic deterrence."[44] Due to their speed and range capabilities, hypersonic weapons may be able to strike targets that were previously only capable of being struck by an ICBM or SLBM, but they are not suitable for all target types. Due to HSW reliance

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[42] Ruby Rusell et al "No First Nukes: Replacing the U.S. Nuclear First Strike Mission with Non-Nuclear Hypersonic Weapons," *Center for Strategic and International studies* (2021):136. http://www.jstor.org/stable/resrep29483.14
[43] Bruce Sugden, "Analyzing the Potential Disruptive Effects of Hypersonic Missiles on Strategic and Joint Warfighting," *Joint Forces* Quarterly 104, (1st Quarter 2022): 9. https://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-104/jfq-104_6-21_Sugden.pdf?ver=i6Gkwx5d8F6Rc2PjVwcQ1Q%3d%3d.
[44] Senate Armed Services Committee, Statement of John E. Hyten, Commander, U.S. Strategic Command, 116th Cong., 1st sess., February 26, 2019, 16, available at <https://www.armed-services.senate.gov/imo/media/doc/Hyten_02-26-19.pdf.

on kinetic energy for destructive purposes, there are certain types of targets that they are not capable of effecting such as hardened deeply buried targets. These targets will still require the attributes that only a nuclear weapon can provide.

The U.S. development of hypersonic weapon technology was initiated under the Conventional Prompt Global Strike (CPGS) program following other projects exploring conventional strike options. CPGS does not have a formal definition but refers to the capability to strike – without the use of a nuclear warhead – quickly anywhere in the world with great precision. In 2006 General James Cartwright [then Commander of United States Strategic Command] stated that a small class of targets existed that the U.S. would only be able to eliminate with nuclear warheads, though using such nuclear assets against this small range of targets would be inappropriate. In 2008, the National Academy of Sciences concluded that "high-value targets having time-sensitive urgency could not be effectively engaged by currently available conventional systems". This emphasizes that there are a few select types of military targets that could only be reached with current nuclear weapons but do not warrant a nuclear strike.[45]

According to Ruby Russell[46], "Conventional PGS weapons could be utilized to target nuclear-armed ballistic missiles in North Korea and, perhaps in the future, Iran. Such conventional missions appear comparable to those envisioned for a nuclear first strike."[47]

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[45] Jonah Bhide, "Hypersonic Weapons: Strategic Drivers and Policy Proposals," *Space and Defense* 12 no.2 (Summer 2021): 76.
https://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=a9h&AN=153089476&site=ehost-live&scope=site.

[46] Ruby Russell is a Foreign Affairs Specialist with the U.S. Department of Energy's National Nuclear Security Administration (DOE/NNSA) Office of Nuclear Verification (ONV).

[47] Ruby Rusell et al, "No First Nukes," 145.

Penetrating advanced integrated air-defense systems is another key rational for developing U.S. hypersonic weapons. Currently, The United States relies on stealth, electronic attack, saturation and low-altitude penetration tactics to defeat such systems. Hypersonic weapons, by virtue of their high speed, high altitude and substantial maneuverability, stress air defenses in fundamentally different ways and represent an attractive option for penetrating defenses well into the future. High speeds compress the battlespace for defensive systems and challenge the performance of interceptors. Their high altitude keeps hypersonic weapons out of reach from most air defense systems.[48]

Hypersonic weapons will be useful in terms of seizing the initiative and surgical targeting of key points that lie at the heart of the adversary's war efforts. Surprise at the tactical level as well as preemption in case of an anti-satellite (ASAT) strike are feasible missions for hypersonic weapons, which could be aimed at crippling the enemy's Command, Control, Communications, Computers, Information, Surveillance and Reconnaissance (C4ISR) systems. Hypersonic weapons could be a valuable addition in both Anti-Access / Area Denial (A2/AD) and counter-A2/AD strategies.[49]

Medium- and intermediate-range hypersonic weapons pose a serious threat to U.S. forces deployed in Europe and the western Pacific by developing A2/AD threats. The U.S. is seeking to neutralize this threat by developing the means to destroy these weapons before they can be used against U.S. and allied forces. Many of these A2 / AD weapons will be on

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[48] Wilkening, "Hypersonic Weapons," 141. Eleni Ekmektsioglou, "Hypersonic Weapons and Escalation Control in East Asia," *Strategic Studies Quarterly* (Summer 2015): 56, https://www.jstor.org/stable/26271074. Jill Hruby, "Hypersonic Delivery Systems," *Nuclear Threat Initiative* (2019): 7. http://www.jstor.org/stable/resrep19984.8.
[49] Ekmektsioglou "Escalation Control," 57.

mobile missile transporter erector launchers (TELs). Attacking mobile missile TELs while they are moving is difficult. To launch, the TEL must stop for a short period of time, during which it is vulnerable. Because this window of vulnerability is short, attacking weapons either have to be very close to the target or travel at very high speeds. Destroying mobile targets while stationary, before they move, is one of the principal rationales for U.S. hypersonic weapons programs.[50]

Defense

The challenges with countering hypersonic weapons are unmistakable; indeed reliably intercepting ICBMs is already difficult to achieve. The further complication is the maneuverability of the hypersonic weapon, meaning the countermeasure must be able to travel at comparative speeds while tracking and adjusting to its target. The compressed response time for countering hypersonic weapons compounds the inherent challenges. Even with the capability to intercept, one must be able to detect a launch, discriminate, and effectively target the weapon, and then prepare and fire one's own interceptor within a few minutes.[51] Utilizing a hypersonic missile to intercept a HSW may be one way to achieve hypersonic defense. The U.S. has recently upgraded the SM-6 to the SM-6 Block IB which has a redesigned body and larger Dual Thrust Rocket Motor, which can help propel the medium-

[50] Wilkening, "Hypersonic Weapons," 136.
[51] John Watts, Christian Troti and Mark Massa," Hypersonic Weapon Defense Systems," *Atlantic* Council (2020): 10-11. http://www.jstor.org/stable/resrep26035.7.

range air defense missile to reach hypersonic speeds. This will assist it when intercepting HSWs in the future.[52]

Two other possible responses to hypersonic threats are hypervelocity projectiles and directed energy weapons. The use of railguns has already been demonstrated to be capable of firing hypersonic rounds. Directed energy weapons have a huge advantage in speed, being able to engage targets at the speed of light. It is unclear that they would be able to prove effective against hypersonic weapons that will have to be pretty solid in construction and lack the 'soft spots' required for laser penetration or disruption. Directed energy weapons can only operate in line-of-sight mode limiting the response time to when the incoming weapon appears over the horizon.[53] Utilizing directed energy weapons (DEWs) may be futile as hypersonic weapons are already shielded against very high temperatures; thus, an extremely high-powered DEW would be needed to destroy them. The pertinent scientific and technological challenges will be immense and so will the associated costs. For the foreseeable future, hypersonic weapons truly represent a new paradigm for all forms of warfare.[54]

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[52] Robert Clark, "On Hypersonic Defense, the USA Has Shown That It Is the Ally That Matters," *The Telegraph* (December 12, 2023): https://www.telegraph.co.uk/news/2023/12/12/hypersonic-missiles-sm6-defence-interceptors-deploying/#:~:text=The%20SM%2D6%20Block%20IB,missile%20to%20reach%20hypersonic%20speeds. Jason Sherman, "Navy Looking to Increase Range, Speed of SM-6 with Larger Rocket Motor," *Inside Defense* (July 18, 2018): https://insidedefense.com/inside-pentagon/navy-looking-increase-range-speed-sm-6-larger-rocket-motor.

[53] Davies, "Hypersonic Weapons," 11.

[54] Bonsignore, "Reasons Why," 34.

Deterrence

Beyond offense and defense measures, HSWs can act as a deterrent against an adversary's aggressive behavior. This section will describe basic deterrence theory and then show how HSWs can fit into this area.

Basic deterrence theory says that a nation attempting to deter another must have the capability and the capacity to carry out what ever deterrent threat is being issued. There must also be the will to follow through with the threat if for some reason deterrence fails. The target of deterrence must have some perception of the credibility of the threat and be willing to be deterred due to the capability, capacity and will of the deterring nation. Below is a simple formula showing the basic deterrence described above laid out in a simple equation. This can be shown below where "C2" is the capability and capacity of the deterring nation, "W" is the deterring nations will, "P" is the Adversary Perception of credibility of the threat and "A" is the adversary willingness to be deterred:

Deterring Nation   Deterrence Target

(C2 X W) X (P X A) = Deterrence Effect[55]

As long as all of the variables of the equation have a value there will be some deterrence effect. If any of these variables are equal to zero then the deterrence effect will equal zero and deterrence fails. No matter the capability and capacity of the deterring nation, the nation to be

[55] Curits McGiffin (4 September, 2018). *Modification of deterrence formula from DSS 601 lecture week 3, Nuclear Weapons and the Strategic Triad.*

deterred (adversary) always has final say. If they refuse to be deterred (A=0), there is no amount of capability or capacity that can change the equation. Deterrence effect will equal zero showing that deterrence will fail.

According to Keith Payne, given the diversity of opponents and the variety of circumstances in which deterrence and assurance will be important goals, a broad spectrum of U.S. strategic capabilities will be necessary. Nonnuclear employment options are likely to be important for punitive and denial deterrence. An example might be a regional contingency where U.S. national survival is not at risk, some opponents may view U.S. nuclear threats as incredible regardless of the character of the U.S. arsenal or the tone of U.S. statements. U.S. advanced nonnuclear threats may be more credible because highly discriminate threats will be more compatible with U.S. stakes and interests.[56] HSWs are one capability that can be utilized to assist in this fashion.

The main focus of the deterrence section will be focused on The Russian Federation and The Peoples Republic of China. Russia and China are currently the only nuclear armed near peer competitors with the United States that are either in the later stages of HSW development or have operationally deployed hypersonic weapons. Although deterrence is an effective measure against many types of threats to include non-nuclear adversaries and possibly even non-state actors, the discussion of these are outside the scope of this paper.

Deterrence by denial attempts to convince an adversary that military and political objectives cannot be accomplished without great cost. This offers the best prospect for

[56] Keith B. Payne, "On Nuclear Deterrence and Assurance," *Strategic Studies Quarterly* 3, no. 1 (2009): 43, http://www.jstor.org/stable/26268917.

persuading Beijing and Moscow to not conduct a large-scale, overt aggression against U.S., allies, and key partners. This approach focuses on threats to defeat the adversary's military operations, denying it the object it seeks. This has been identified as the most effective form of deterrence if one relies on conventional capabilities. This form of deterrence is likely to fail if the adversary perceives that it has the opportunity for a quick and easy win, in other words the ability to impose a fait accompli on the United States and its allies.[57]

The idea of integrating conventional systems into the broader U.S. deterrent strategy is not a new one and has been considered seriously by multiple U.S. administrations over the last two decades. These considerations present themselves most clearly within promotion of Conventional Prompt Global Strike (PGS), a system designed "to maintain and enhance its long-range strike capability so that it can strike anywhere in the world with forces that are based in or near the United States." Within the context of this program, General James Cartwright, then Commander of United States Strategic Command, testified to Congress in 2005 about the potential for the United States to develop a 'New Triad Concept' which "joined long-range nuclear-armed missiles with precision-strike conventional weapons in a category called offensive strike weapons." During the testimony, General Cartwright and other suggested that "if missiles could deliver their payloads more precisely to their targets, then, for some categories of targets, they may not need the explosive yield of a nuclear weapon to destroy the target," General Cartwright emphasized at the time that "the substitution of conventional

[57] Jacob Heim, *A Strategy-Driven Approach to the Research and Development of Hypersonic Missiles*, Perspective, (RAND, 2023), 8.

warheads for nuclear warheads in the U.S. war plan would require significant improvements in the accuracy of U.S. long-range ballistic missiles."[58]

Nearly two decades later, it seems possible that the advent of highly maneuverable, precision-guided HSWs can finally carry out the mission envisioned by General Cartwright, wherein non-nuclear systems play a meaningful role within the broader U.S. strategic deterrent. Consider a nuclear deterrent complemented by a conventional first-use system capable of travelling at hypersonic velocities while also maneuvering in flight, allowing for the circumvention of modern layered missile defenses and the ability to strike targets with greater precision.[59] The integration of non-nuclear strategic forces into the U.S. extended deterrent could help close this credibility gap. Specifically, it seems possible that the use of non-nuclear HSWs, capable of evading defense systems and penetrating strategic targets all at hypersonic speeds, could serve as a more credible, and therefore meaningful, extended deterrent.[60]

Russia is also looking at utilizing hypersonic weapons for deterrence purposes. Russia's immediate application for hypersonic weapons in Europe is to reinforce the most salient message that Russia hopes to send, that NATO cannot protect you. By displaying capabilities Moscow seeks to discredit NATO's security guarantees and coerce compliance from surrounding nations. By emphasizing NATO's physical and psychological vulnerability, Moscow means to deter the alliance from opposing Russian aggression. These threats are heightened by the added potential of Russian nuclear capability, supported by their doctrine for the use of low-yield nuclear weapons in a regional conflict, which further emboldens Russian aggression.

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[58] Russell et al, "No First Nukes," 143.
[59] Russell et al, 143.
[60] Russell et al, 146.

Russian hypersonic weapons increase the cost to NATO in organizing a combat response to Russian grey zone aggression.[61]

The previous sections of this chapter discussed the broader reasons of why a nation may decide to develop HSWs including offensive capabilities, defensive capabilities and deterrence. The next chapter will discuss the main nations that are working to or have already developed and deployed HSWs. Due to the rapidly evolving environment of HSWs, this list of nations and capabilities will vary with time.

[61] Cummings, "Hypersonic Weapons: Tactical Uses and Strategic Goals," *War on the Rocks*, November 12, 2019, https://warontherocks.com/2019/11/hypersonic-weapons-tactical-uses-and-strategic-goals/.

Nations Developing Hypersonic Strike Weapons and Their Expected Uses

Many nations throughout the world have been working on the development of HSWs for years if not decades. This list includes a multitude of nations, including the U.S., its allies and adversaries. The reasons why nations are looking at developing hypersonic weapons vary as much as the nations that are working on hypersonic development. The below section will cover the major nations working on HSW research and development and how they intend to use them once these weapons become operational.

United States

The inception of the current United States hypersonic weapons program dates back to 2003 when the Bush administration sought a CPGS capability that would allow targets to be struck anywhere in the world within an hour. The major threat at the time was terrorism, which often presented itself with small windows of opportunity for attack. This led to the demand for a long-range high-precision conventional strike capability. In addition to counter-terrorism, this new capability was envisioned to provide the U.S. with a unique 'counter-nuclear' capability enabling it to target nuclear facilities and infrastructure at any place where an emerging threat existed.[62]

[62] Sander Aarten, "The Impact of Hypersonic Missiles on Strategic Stability: Russia, China and the US," *Militaire Spectator Jaargang*, 189, no.4 (2020): 184, John Watts, Christian Troti and Mark Massa," Pulse Check: Tracking Hypersonic Weapons Development of the Indo-Pacific Powers," *Atlantic* Council (2020): 10-11. http://www.jstor.org/stable/resrep26035.8.

While he was Vice Chairman of the Joint Chiefs of Staff General John Hyten stated, Hypersonic weapons could embody "responsive, long-range, strike options against distant, defended, and/or time-critical threats [such as road mobile missiles] when other forces are unavailable, denied access or not preferred." The Pentagon plans to deploy hypersonic weapons from a variety of delivery capabilities and vessels that do not require basing on foreign soil, thereby circumventing, or at least mitigating, the regional A2 / AD challenges.[63] The 2018 *National Defense Strategy* identifies hypersonic weapons as one of the key technologies "[ensuring the United States] will be able to fight and win the wars of the future."[64]

Hypersonic weapons will provide new response options in the face of adversary counter-space actions. The United States is disproportionately reliant on space-based assets to enable functions like surveillance, communication, and precision navigation. A rapid strike capability will allow U.S. forces to disable command uplinks to the anti-satellite weapon before it achieves its effect, especially those targeting higher orbits or designed for co-orbital rendezvous/collision. Given the prospect of losing some space-based capability, the short flight times of hypersonic weapons give the United States an option to inflict damage before its own space-based enabler is lost. Both options support a plausible response to anti-space attacks which may deter anti-satellite launches in the first place.[65]

U.S. forces must be able to deter, defend against, and defeat aggression by potentially hostile nation-states. This capability is fundamental to the nation's ability to defend its interests

[63] Watts, Trotti and Massa, "Tracking Indo-Pacific," 13.
[64] Jim Mattis, "Summary of the 2018 National Defense Strategy: Sharpening the American Military's Competitive Edge," 2018, 3, https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.
[65] Cummings, "Strategic Goals."

and to provide security in key regions. Anti-access strategies seek to deny outside countries the ability to project power into a region, thereby allowing aggression or other destabilizing actions to be conducted by the anti-access power. Without dominant U.S. capabilities to project power, the integrity of U.S. alliances and security partnerships could be called into question, reducing U.S. security and influence and increasing the possibility of conflict.[66] HSWs are one weapon system that will allow access into these denied areas, allowing other systems such as aircraft and maritime assets the ability to project power.

As it is increasingly difficult to blunt and roll back adversarial attacks with forward-deployed U.S. and allied assets, the United States must maintain the ability to strike quickly at the outset of a conflict, both from within the region and from beyond. These strikes would prioritize command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) networks and integrated air-and missile-defense (IAMD) systems, which form the foundation of U.S. competitors' A2 / AD strategies.[67]

According to the 2022 National Defense Strategy of the United States of America a wide range of new or fast-evolving technologies and applications are complicating escalation dynamics and creating new challenges for strategic stability. Hypersonic weapons are one of these new technologies that must be taken into account.[68] One of the four main defense priorities listed in the U.S. National Defense Strategy is "deterring aggression, while being

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[66] Ekmektsioglou "Escalation Control," 48. Department of Defense, Quadrennial Defense Review Report, Washington, DC: DOD, February 2010., 31.
https://dod.defense.gov/Portals/1/features/defenseReviews/QDR/QDR_as_of_29JAN10_1600.pdf.
[67] Watts, Trotti and Massa," Tracking Indo-Pacific," 12-13.
[68] Department of Defense, *National Defense Strategy of the United States of America, Including the 2022 Nuclear Posture Review and the 2022 Missile Defense Review,* (Washington, DC: DOD, October 2022), 6, https://apps.dtic.mil/sti/trecms/pdf/AD1183514.pdf.

prepared to prevail in conflict when necessary – prioritizing the PRC challenge in the Indo-Pacific region and the Russia challenge in Europe."[69] HSWs will be instrumental in future U.S. deterrence-by-denial operations involving China and Russia. A four-element approach for U. S. power projection could meet the demands of deterrence-by-denial scenarios involving these two main adversaries. This approach addresses the capability for rapid effective forward operations at scale, the ability to conduct strikes inside of a contested battlespace from the outset of hostilities, the ability to generate rapid and survivable combat power both inside and outside the reach of enemy strike systems, and the ability to asymmetrically reduce the adversary's remaining military force. In order to accomplish this, the U.S. will have to accomplish the following goals:

(1) U.S. forces, as well as enabling and sustainment capabilities, need to be postured in a way that enables effective forward operations at scale within hours or days of preparation. Hypersonic weapons would need basing modes that enable operations with limited preparations. This could include forward basing (e.g. ground-based missiles positioned within range of their targets) and platforms that can rapidly deploy to launch baskets such as maritime and airborne assets.

(2) U.S. forces need to be able to conduct strikes inside the contested battlespace from the outset of hostilities. The major advantage for hypersonic strike weapons is for the types of targets they can engage. Ideally, these weapons would be able to strike adversary defenses, enabling other parts of the joint force access to sink ships and destroy military vehicles.

[69] Department of Defense, *National Defense Strategy of the United States of America,* 7.

(3) U.S. forces need to be able to generate rapid and survivable combat power both within (inside) and beyond (outside) the reach of enemy strike systems in the face of continued and adaptive enemy attack. Hypersonic strike weapon ranges would permit them to be part of both the "inside" and "outside" forces. The United States will need a deep inventory of long range weapons that can sustain a volume of fire. Having blunted the enemy's invasion, U.S. forces need to asymmetrically reduce the adversary's remaining military forces.[70]

The United States is currently developing multiple prototypes of hypersonic weapons. The Air Force's AGM-183A Air-Launched Rapid Response Weapon (ARRW); the Army's Long Range Hypersonic Weapon (LRHW); and the Navy's Intermediate Range Conventional Prompt Strike (CPS). Each is designed to strike targets with a conventional warhead at intermediate range (1500-3000 nautical miles).[71]

Australia

The University of Queensland (UQ) has a long history of work in hypersonics and developed and flight-tested scramjet engines at speeds of up to Mach 9.5 under its HyShot program from 1998-2006. That program evolved into the HiFire program, a collaborative venture between the UQ, the Defense Science and Technology Organization (now DST Group) and Boeing. The goal of this program was to perform several hypersonic flight experiments at while making them affordable at a cost of between $5 million to $10 million a test. After HIFire finished in 2018, DST Group and UQ continued collaborative work on scramjets and alternative

[70] Heim, *Strategy-Driven Approach*, 9-10.
[71] Stephen Cimbala and Adam Lowther, "Hypersonic Weapons and Nuclear Deterrence," *Comparative Strategy* 41 no.3, (April 15, 2022): 283.

propulsion systems. The DST Group also works with its American Counterparts in classified weapons and countermeasures work. UQ is home to the Centre for Hypersonics, which has an active research program with contributions from researchers form Australian and international universities and from industry partners, including Boeing and BAE Systems.[72]

Australia's most vital strategic requirement for defense of the country is the ability to deny avenues of approach to any adversary through the narrow littoral and land approaches of the Indonesian archipelago. Australia is prioritizing longer-range strike weapons and related capabilities "to hold adversary forces and infrastructure at risk further from Australia." In the air domain this will include hypersonic weapons.[73]

United Kingdom

The United Kingdom (UK) has joined the hypersonic missile race and has allocated around £12 million for research and development. As per the existing plans, the development of hypersonic propulsion systems could be completed in the next two years. The Project Tempest, which is being developed, is likely to be completed in 2030s with a futuristic fighter carrying laser and hypersonic weapons.[74]

The UK is looking to utilize hypersonic weapons to penetrate adversary A2 / AD systems among other applications. According to UK Air Chief Marshal Sir Stephen Hillier "Arguably the

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[72] Davies, "Hypersonic Weapons," 2-3, Vivienne Machi, "Future Weapons: Rivals Push Pentagon to Boos Funding for Hypersonics Research," *National Defense* 102, no.764 (2017): 32, https://www.jstor.org/stable/27021835.
[73] Watts, Trotti and Massa," Tracking Indo-Pacific," 19.
[74] Sultan and Khursheed, "Implications for Strategic Stability.", Andrew Chuter, "British Military Scrambles to Speed up Work on Hypersonic Engines, Weapons," *Defense News* (July 18, 2019): https://www.defensenews.com/global/europe/2019/07/18/british-military-scrambles-to-speed-up-work-on-hypersonic-engines-weapons/.

most important reason [to develop hypersonic weapons] is that over the last three decades we have enjoyed unparalleled advantage in air and space allowing us to do operations in Syria, Iraq, Libya, and elsewhere. Potential adversaries have spotted this, and we now face increasingly sophisticated integrated air defense systems. Their goal is to deny us access to their airspace, if we can't get access to an adversary airspace then we really do have a problem. One way to get around that is speed."[75]

Japan

The 2019 Japanese budget included 6.4 billion Yen ($58 million US) for research and development on a hypersonic scramjet-powered cruise missile and a 13.8 billion yen ($126 million US) for the development of a Hyper Velocity Gliding Projectile (HVGP). In November 2019, the Japanese Ministry of Defense (MOD) distributed an English-language primer on defense goals that included a goal for a Mach 5+ hypersonic scramjet cruise missile by 2030 and a boost-glide hypersonic missile by 2035. The hypersonic vehicles will carry two different warheads for different targets. The first – an armor-piercing warhead – is designed to render the deck of an aircraft carrier inoperable. The second, an explosive-formed penetrator, is designed to destroy A2 / AD nodes. These missiles will be deployed to Japan's southernmost bases to allow force projection into remote islands without necessarily deploying the Japanese Self-Defense Force. In order to meet this requirement, Japan has planned for its missiles to have a roughly two-hundred-mile range. Japan envisions using these missiles from standoff

[75] Churter, "British Military."

ranges to negate offensive systems that hold Japanese Self-Defense Force (SDF) personnel at risk.[76]

Japan's Ministry of Defense is looking to partner with the United States on a railgun program that could be used to counter hypersonic weapons. Japan has strengths in material sciences for construction of the rails and gun, but would need to utilize U.S. assistance with system power storage and guidance system. Although rail guns have multiple applications such as long-range artillery, Japan sees hypersonic defense as the guns primary purpose. A key for rail guns in not just the potential speed (hypersonic) and range, but the cost per shot versus a missile. Conventional munitions require propellants and are costly to produce. Railguns require only a solid piece of metal to do damage, relying on the mass and velocity of the projectile.[77]

Germany

Germany successfully tested an experimental hypersonic glide vehicle (SHEFEX II) in 2012; but may have later pulled funding for the program. German defense contractor DLR continues to research and test hypersonic vehicles as part of the European Union's ATLLAS II project, which seeks to design a Mach 5-6 vehicle.[78]

[76] Watts, Trotti and Massa," Tracking Indo-Pacific," 21.
[77] Stew Magnuson, "Long Range Fires: Japan Looks to Partner with U.S. on Railgun Project," *National Defense* 107 no.834 (May 2023): 20. https://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=a9h&AN=163357754&site=ehost-live&scope=site.
[78] Sayler, "Hypersonic Weapons: Background and Issues for Congress," *Congressional Research Service* R45811, (February 13, 2023): 21. https://sgp.fas.org/crs/weapons/R45811.pdf.

France

France has previously collaborated and contracted with Russia on the development of hypersonic technology. France is currently contracted with the French Ariane Group for domestic development of hypersonic technology. France recently publicized its intent to weaponized hypersonic technology, after working on it for the better part of three decades. Under the V-Max (experimental Maneuvering Vehicle) program, France plans to modify its air-to-surface ASN-4G supersonic missile for hypersonic flight. Some analysts believe that the V-Max program is intended to provide France with a strategic nuclear hypersonic weapon.[79]

France is moving towards HSW, developing a fourth-generation air-to-ground nuclear missile (ASN-4G) to be put into service in the 2035 time frame. In parallel, the V-MAX experimental project aimed at developing a hypersonic glider was granted to the Ariane Group by the French Directorate General of Armaments in 2019. This project aims to develop technological building blocks related to the hypersonic glider, whose future use has yet to be decided (conventional or nuclear). This new maneuvering HCM will guarantee the credibility of the French deterrent's airborne component beyond 2040.[80]

In June 2023 France became the second Western nation to test hypersonic technology with a successful test of a sounding rocket carrying a VMaX hypersonic glider. This positive test places France in a small group of nations that have shown the capability to produce and test hypersonic weapons.[81]

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[79] Sayler "Issues for Congress," 21.
[80] Pappalardo, "Rhetoric," 83, Sayler, "Issues for Congress," 21.
[81] Parth Satam, "Hypersonic Race Heats Up! France Becomes 2nd Western Country to Test Hypersonic Tech as US Struggles and Russia & China Lead," *The EurAsian Times,* June 30, 2023, https://www.eurasiantimes.com/hypersonic-race-heats-up-france-becomes-2nd-western-country/.

India

India has advanced its ongoing research and development in collaboration with Russia on the BrahMos series of missiles as a response to robust regional air and sea defenses. The BrahMos Aerospace is an Indo-Russian multinational aerospace and defense corporation, with the core manufacturing concentrations in cruise missiles. It was founded as a joint venture between India's Defence Research and Development Organisation and NPO Mashinostroyenia of Russia. India and Russia are currently working to jointly develop an extended range Brahmos missile capable of ranges greater than 600 km.[82]

The first BrahMos missile – a supersonic ramjet powered cruise missile – can be launched from air or sea and has been exported to countries including Vietnam. Russia and India are collaborating on the BrahMos II designed to fly at speeds up to Mach 7 using a scramjet.[83]

India could be building hypersonic weapons for three possible scenarios: (1) India could use these missiles for launching limited strikes against Pakistan. This would preclude the possibility of losing a manned aircraft as was the case in February 2019 surgical strike, when India lost two of its aircraft causing a significant blow to its military prestige. (2) India could use hypersonic weapons to launch counterforce strikes and create a 'shock and awe' impact. Such a strike would push the adversary to retaliate with full force, which may include nuclear weapons that may cause more damage than the envisioned gains. (3) India could develop a counterforce

[82] Smriti Jain and Arunava Biswas, "BrahMos missile with higher range: This 'killer' India-Russia Project Will Scare Pakistan and China," *Financial Express,* October 19, 2016, https://www.financialexpress.com/india-news/brahmos-missile-range-highlights-india-russia-modi-putin-mtcr-pakistan-china/424178/.
[83] Watts, Trotti and Massa,"Tracking Indo-Pacific," 21.

strike capability and use it as a deterrent to prevent Pakistan from the early deployment of its tactical nuclear weapons, which could offer space for its Cold Start Doctrine (CSD).[84]

The main purpose of India's CSD is to give a "punishing" reply to Pakistan in case of any alleged terrorist attack on Indian soil with totally different orientation of the Indian armed forces from defensive to offensive. The Indian army would carry out swift, quick and offensive joint operations essentially military based, including components of air support which may also include naval components. HSWs would fit in well with this doctrine, allowing rapid strikes on Pakistan, without the threat to Indian forces, creating an element of surprise and giving Pakistan no time to respond.[85]

India's development of hypersonic cruise or boost-glide missiles is only adding to the instability of the regional deterrent situation. Nuclear or not, an arsenal of perceived defense-defeating, first-strike capabilities can theoretically penetrate and eliminate much of Pakistan's nuclear force. This could cause Pakistan to alter its defense posture. In addition to Pakistan maturing its nuclear force to include SLBMs and solid-fuel rockets, deterrence stability would improve if Pakistan and India were both to develop and procure hypersonic boost-glide or cruise missile capability. This provides both Pakistan and India the capability to defeat antiballistic missile systems, placing both opponents in a stronger assured vulnerability state.[86]

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[84] Sultan and Khursheed, "Implications for Strategic Stability."
[85] Masood Khattak, "Indian Cold Start Doctrine: Capabilities and Limitations," (2010): 3. Accessed on 14 October 2023, DOI:10.13140/RG.2.2.29208.19203.
[86] Reny, "Nuclear-Armed," 65.

Russia

Russia often cites U.S. withdrawal from the ABM treaty and mobilization of missile defenses both domestically and worldwide as motivating factors for accelerating their weapons development.[87] President Vladimir Putin stated in 2018 that Russia was categorically against U.S. withdrawal from the ABM treaty. "We saw the Soviet – U.S. ABM treaty signed in 1972 as the cornerstone of the international security system."[88] According to the 2021 National Security Strategy of the Russian Federation, The United States continues to develop global missile defense capabilities and has pursued a consistent policy of abandoning international arms control commitments. The planned deployment of U.S. intermediate-range and shorter range (can be read as the LRHW specifically) missiles in Europe and the Asia-Pacific region poses a threat to strategic stability and international security.[89]

For Russia, hypersonic weapons are primarily a means to reinforce Russia's second-strike nuclear capabilities. Russian officials have long feared that advances in U.S. offensive missiles and missile-defense technology will eventually produce a first-strike capability. Specifically, the Kremlin believes that the United States could conduct a decapitating first strike with conventional missiles and then defeat Russia's remaining retaliatory strikes with advanced missile defenses. Russia perceives this as an existential threat, causing the Kremlin to seek a set of capabilities that can hedge against current and future U.S. advances, thereby ensuring Russia's nuclear deterrent.[90]

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[87] Wil Powell et all, "The Hypersonic Weapon Threat: Resilient Deterrence Despite Destabilizing Buzzwords," *Center for Strategic and International Studies* (February 1, 2023): 141. https://www.jstor.org/stable/resrep47437.14.
[88] Putin, "Presidential Address."
[89] Russian Federation, (2021), *Russian National Security Strategy,* July 2021, 14, https://paulofilho.net.br/wp-content/uploads/2021/10/National_Security_Strategy_of_the_Russia.pdf.
[90] Watts, Trotti and Massa," Tracking Indo-Pacific," 15.

Until recently Russia has primarily focused on hypersonic technology's use for delivering its nuclear warheads. The dual capability (conventional or nuclear) as well as HSW high penetrability through active defenses make it an appealing system for the Russian Federation as it ensures the flexibility of implementing strategic deterrence by keeping the door open to both conventional and nuclear strike options while also challenging the United States' regionally deployed missile defense systems.[91]

While nuclear deterrence is the Kremlin's primary strategic objective for hypersonic capabilities, it is not the only one. Russia is also developing hypersonic missiles that can target U.S. carrier strike groups, as well as sea-based and land-based missile-defense systems, thereby supplementing Russia's A2 / AD strategy.[92]

Russia is currently developing three main hypersonic weapons. All three systems look to be dual capable once completed which will complicate the situation when they are utilized in combat. The three systems consist of an ICBM (Avangard), and Air Launched Ballistic Missile (ALBM) (Kinzhal) and a hypersonic cruise missile (Tsirkon).

The Avangard is a standard boost-glide vehicle which is lifted into space using a multi-stage ballistic missile and then released in low-earth orbit, descending to the edge of the atmosphere and gliding to hypersonic speeds. The Avangard is a dual capable system with a warhead that can be either conventional or nuclear.[93] The Russian Avangard system has a range of over 6000 kilometers and can change course while mid-flight through the atmosphere. In April of 2022 Russia tested its new intercontinental ballistic missile, Sarmat, which will carry the

[91] Estes, "Framework," 28.
[92] Watts, Trotti and Massa," Tracking Indo-Pacific," 16.
[93] Hruby, "Delivery Systems," 20-21.

nuclear capable hypersonic boost-glide vehicle, Avangard. With this configuration, Russian hypersonic weapons can hit Finland in less than 30 seconds and reach the U.K. in less than 4 minutes.[94] With the Avangard's ability to complicate and reduce an opponent's missile attack warning assessment and response timeline, U.S. decision makers might interpret the inbound HFGV as a nuclear threat and begin the process of launching a nuclear retaliatory strike.[95]

The Kinzhal is an air-launched hypersonic ballistic missile that can be deployed from the Mig-31 and Su-34 fighters. Russia is working to eventually deploy this missile on the Tu-22M3 strategic bombers. The Kinzhal is claimed to have a maximum speed of Mach 10 and a range of up to approximately 2000 kilometers. This weapon is designed to target missile-defense installations and carrier strike groups as part of Russia's A2 / AD strategy.[96] Russia has fielded the Kinzhal and launched it from a MiG-31 interceptor aircraft in Ukraine in 2022.[97]

The Tsirkon is a two-stage hypersonic cruise missile that can reach speeds of approximately Mach 9 and strike a target more than 1000 km, (620 miles) away. The first stage uses a solid-fuel rocket to lift and accelerate the missile to hypersonic speeds, and the second phase uses a scramjet to continue propelling the missile at hypersonic speeds to the target. It can be launched from surface ships or submarines.[98] The Tsirkon is designed to destroy carrier groups before it can be intercepted and is also capable of striking ground targets. At hypersonic speeds and a relatively short travel distance, the time to detect and engage a Tsirkon would be

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[94] Connie Lee, "China, Russia Hypersonic Programs: Real Progress or Bluster," *National Defense* 104, n0.788 (2019): 33. Melissa Rossi, "Will the Race to Develop Hypersonic Weapons Spark the Next Global Arms Race," Yahoo News, accessed July 5, 2022, https://news.yahoo.com/will-the-race-to-develop-hypersonic-weapons-spark-the-next-global-arms-race-110025468.html. Sayler, "Issues for Congress," 15.

[95] Sugden, "Disruptive Effects," 12.

[96] Davies, "Hypersonic Weapons," 10, Watts, Trotti and Massa," Tracking Indo-Pacific," 17.

[97] Sayler, "Issues for Congress," 16-17.

[98] Hruby, "Delivery Systems," 20-21.

less than 5 minutes. Current ship-based defenses are not designed to work at those short time intervals. Tsirkons that are carried by submarines could target land-based command and control centers or missile-defense installations by moving close to shore (a few hundred kilometers from the coast).[99] Russia launched its Tsirkon HCM in combat for the first time on 7 February 2024 in the current Russia-Ukraine conflict. This is the second type of HSW that Russia has utilize in this conflict.[100]

Russia's Kinzhal hypersonic ballistic missile and its Tsirkon hypersonic cruise missile bear significant implications of the United States' ability to defeat enemy A2 / AD defenses. When nuclear armed, these systems will supplement Russia's regional nuclear capability, providing coercive leverage over the United States, NATO, and other European countries.[101]

China

China's growing arsenal of hypersonic missiles of various ranges includes nuclear and conventional warheads. "China is testing a (nuclear armed) intercontinental-range hypersonic glide vehicle, which is designed to fly at high speeds and low altitudes, complicating the U.S. ability to provide precise warning."[102] According to congressional testimony from nuclear policy expert Henry Sokolski plausible projection for the decade of 2025-2035 includes the following assumption: "China will continue to develop accurate nonnuclear missiles that can target the continental United States with maneuverable reentry vehicles and hypersonic

[99] Hruby, "Delivery Systems," 24, Sayler, "Issues for Congress," 16.
[100] Brad Lendon, "Russia Used an Advanced Hypersonic Missile for the First Time in Recent Strike, Ukraine Claims," CNN, last modified 13 February, 2024. https://www.cnn.com/2024/02/13/europe/ukraine-russia-zircon-hypersonic-missile-intl-hnk-ml/index.html.
[101] Watts, Trotti and Massa," Tracking Indo-Pacific," 17.
[102] Cimbala and Lowther, "Comparative Strategy," 283-284.

technologies. China would also use intermediate, medium, and shorter-range versions of such missiles to threaten America's regional friends and allies."[103]

Beijing seeks to prevent the United States from intervening in portions of the Western Pacific that it sees as a privileged sphere of influence.[104] Hypersonic capabilities allow Beijing more options for simultaneously striking ships at sea, forces ashore, and command functions using a force posture that appears deceivingly routine. According to the 2020 Defense Department report on China's military power, Beijing is pursuing HGVs as a necessity to counter U.S. and other countries' ballistic missile defenses; intelligence surveillance, and reconnaissance; and precision strike systems.[105]

China seeks freedom of action in the South and East China Seas. It therefore aims to deter the U.S. from interfering in that region and seeks to weaken Washington's security guarantees to regional states. One way China looks to do this is by pursuing a hypersonic missile capability. China publicly displayed the DF-17 HGV on 1 October 2019 at the Communist Party's 70th birthday military parade. With a range of 1500 kilometers (approximately 1000 miles) the missile easily covers China's first island chain which adds to Beijing's ability to deny foreign navies' access to the South and East China Seas.[106] The first island chain (FIC) refers to the first chain of major Pacific archipelagos out from the East Asian continental mainland coast. It is principally composed of the Kuril Islands, the Japanese archipelago, the Ryukyu Islands, Taiwan

[103] Cimbala and Lowther, "Comparative Strategy," 283-284.
[104] Cummings, "Strategic Goals."
[105] Shannon Bugos and Kingston Reif, "Understanding Hypersonic Weapons: Managing the Allure and the Risks," *Arms Control Association*, (September 2021): 13, https://safe.menlosecurity.com/doc/docview/viewer/docN6FCA22980417ae7ab14a2d486c14429c5ca0f91b56119 1f2517bb4779e66ed582c04a8bf7c71. OSD, "Security Developments, China," 87.
[106] Sander Aarten, "Strategic Stability," 188.

(Formosa), the northern Philippines, and Borneo, hence extending all the way from the Kamchatka Peninsula in the northeast to the Malay Peninsula in the southwest. Figure 2 depicts the layout of the FIC in red.

Figure 2. First Island Chain

China currently has several hypersonic missile programs either under development and testing or in the field.

The DF-ZF HGV (previously known as the WU-14) has a range of roughly 1930 kilometers. This vehicle has been tested at least nine times since 2014. The DF-ZF is the Chinese HGV and is capable of being placed on top of multiple Chinese missile types as laid out below.

The DF-17 is a ground launched medium range system (1800-2500 kilometers) designed to carry HGVs for use against ground targets and surface ships. The DF-17 was assessed to achieve operational capability in 2019 and carry the DF-ZF HGV listed above.[107]

The DF-21 Medium range ballistic missile and the DF-26 intermediate range ballistic missile are also being utilized to carry HSWs. These missiles could support an anti-access / area-denial strategy maintaining Chinese strike capability out past the second island chain.

The CM-401 is a ship-launched cruise missile similar to the Russian Zircon and can also be launched from land. It is intended for rapid and precision strikes against medium-size ships, naval task forces, and offshore facilities.[108]

The DF-100 which is designed to bolster China's counter-intervention strategy of keeping U.S. or other adversary forces away from its coast is a hypersonic regional-level anti-ship missile that will impose a new, challenging threat-vector for long-range attacks against large warships over a thousand miles from China's coastline. These sea and land launched cruise missiles strengthen what the United States calls China's anti-access / area denial strategy, which the PLA calls a counter-intervention campaign.[109]

In the summer of 2021 China tested a hypersonic glide vehicle off of a Long March rocket which made a partial orbit of the earth before diving toward its target. In late November 2022 the Pentagon released details about China's new system, reporting that the glide vehicle

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[107] Davies, "Hypersonic Weapons," 10, Powell et all "Hypersonic Weapon Threat," 142, Sugden, "Disruptive Effects," 8.

[108] Larry Wortzel*, Hypersonic Weapons Development in China, Russia and the United States – Implications for American Security Policy*, Land Warfare Paper 143, (Association of the United States Army, March 2022), 3, https://www.ausa.org/publications/hypersonic-weapons-development-china-russia-and-united-states-implications-american.

[109] Wortzel, *Hypersonic Weapons Development,* 3.

traveled almost 25000 miles during the 2021 test and reached hypersonic speeds. The system fit all characteristics of a fractional orbital bombardment (FOB) system. The combo is called a fractional orbital hypersonic delivery system, it is faster than an intercontinental ballistic missile and more difficult to track.[110]

Hypersonic weapons will bring massive advantages in speed and range to the Chinese military. These advantages will greatly support China's military strategy furthering Chinese strategic objectives and ambitions. The development of hypersonic weapons is a key enabler of China's military strategy of Limited Regional War of Informationization to ensure China's defense by projecting long-range offensive operations, using superior capabilities, to attack an adversary's weak points.[111]

North Korea

North Korea tested the Hwasong-8 – which it identifies as a hypersonic glide vehicle – in September 2021. Reports indicate that the vehicle may have reached speeds of only Mach 3 making it supersonic, not hypesonic. North Korea claims to have tested a second hypersonic weapon in January 2022; however, experts believe that weapon may instead be a maneuvering reentry vehicle (MaRv).[112] Although MaRvs travel at hypersonic speeds, because of a purely ballistic trajectory, they don't meet the definition of HSWs.

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[110] Gupta, "Orbital Delivery System."
[111] Ralph Bently, *Strategy at Mach 5: Chinese Military Strategy*, Air University, (September 10, 2021): https://www.airuniversity.af.edu/Wild-Blue-Yonder/Article-Display/Article/2771133/strategy-at-mach-5-hypersonic-weapons-in-chinese-military-strategy/.
[112] Sayler, "Issues for Congress," 21.

North Korea recently tested a solid fueled Intermediate Range Ballistic Missile (IRBM) with an HGV on January 15, 2024. The operationalization of this system would make current South Korean and Japanese missile defense systems irrelevant.[113]

There are many nations that are currently developing HSWs, both U.S. allies and adversaries. This list of nations will only increase in the future as the technology becomes more accessible and economical to produce. As more nations continue to produce HSWs this will only complicate the strategic landscape.

The previous section discussed nations currently working on HSW technology, which ones have HSWs or are expected to have HSWs in the future. It also provided a broad overview on how the three major near peer competitors (U.S., Russia, and China) may look at utilizing these weapons.

The following chapter will focus on developing an understanding of strategic stability concepts and theories. For the purposes of limiting space taken by this discussion, the focus of the next chapter will be on the strategic relationships between the three near peer nuclear competitors, The U.S., Russia, and China and how HSWs may affect their relationship.

The following table (table 2) summarizes the current HSWs either under development or currently being fielded by the three major powers, the United States, Russia and China.

[113] Brad Lendon and Yoonjung Seo, "North Korea Claims Another Successful Test of its Hypersonic Glide Missile Tech.," CNN, last modified 15 Jan 2024, https://edition.cnn.com/2024/01/14/asia/north-korea-ballistic-missile-intl-hnk/index.html.

Table 2. HSWs of the United States, Russia and China.

Country	Weapon Name	Weapon Type	Range	Max Speed	Warhead Type
United States	LRHW (Long Range Hypersonic Weapon)[114]	HGV	>1725 mi	Mach 17	Conventional
United States	HACM (Hypersonic Attack Cruise Missile)[115]	HCM	>600 mi	Mach 6	Conventional
United States	ARRW (Air-Launched Rapid Response Weapon)[116]	HGV	> 1000 mi	Mach 8	Conventional
United States	CPS (Conventional Prompt Strike)[117]	HGV	> 1725 mi	Mach 17	Conventional
Russia	Avangard[118]	HGV	> 3750 mi	Mach 28	Nuclear
Russia	Kinzhal[119]	ALBM	1200 mi	Mach 10	Conventional / Nuclear
Russia	Tsircon (Zircon)[120]	HCM	620 mi	Mach 9	Conventional / Nuclear
China	DF-17 (DF-ZF)[121]	HGV	1200 mi	Mach 10	Conventional / Nuclear
China	DF-21 (DF-ZF)[122]	HGV	1900 mi	Mach 10	Conventional / Nuclear

[114] Andrew Feikert, "The U.S. Army's Long-Range Hypersonic Weapon (LRHW)," Congressional Research Service, IF11991, Updated December 8, 2023. available: https://crsreports.congress.gov/product/pdf/IF/IF11991.
[115] "Hypersonic Missile Integration with Aircraft," Airforce Technology, August 14, 2023, https://www.airforce-technology.com/analyst-comment/hypersonic-missiles-aircraft-integration/.
[116] Sayler "Issues for Congress," 7.
[117] Sidney E. Dean, "Conventional Prompt Strike: The US Navy's Hypersonic Weapons Programme," European Security and Defense, April 12, 2023. https://euro-sd.com/2023/04/articles/30723/conventional-prompt-strike-the-us-navys-hypersonic-weapons-programme/.
[118] Missile Defense Project, "Avangard," Missile Threat, Center for Strategic and International Studies, January 3, 2019, last modified July 31, 2021, https://missilethreat.csis.org/missile/avangard/
[119] Missile Defense Project, "Kh-47M2 Kinzhal," Missile Threat, Center for Strategic and International Studies, March 27, 2018, last modified March 19, 2022, https://missilethreat.csis.org/missile/kinzhal/.
[120] "3M22 Zircon: What is Known About Missile that Russia Could Have Launched at Kyiv," Ukrinform, February 12, 2024, https://www.ukrinform.net/rubric-ato/3826177-3m22-zircon-what-is-known-about-missile-that-russia-could-have-launched-at-kyiv.html
[121] Missile Defense Project, "DF-17," Missile Threat, Center for Strategic and International Studies, February 19, 2020, last modified August 2, 2021, https://missilethreat.csis.org/missile/df-17/.
[122] Missile Defense Project, "DF-21 (CSS-5)," Missile Threat, Center for Strategic and International Studies, April 13, 2016, last modified March 28, 2022, https://missilethreat.csis.org/missile/df-21/.

Table 2. HSWs of the United States, Russia and China (continued).

Country	Weapon Name	Weapon Type	Range	Max Speed	Warhead Type
China	DF-26 (DF-ZF)[123]	HGV	2500 mi	Mach 10	Conventional / Nuclear
China	DF-31 (DF-ZF)[124]	HGV	7500 mi	Mach 10	Conventional / Nuclear
China	CM-401[125]	HCM	180 mi	Mach 5	Conventional
China	DF-100 (CJ-100)[126]	HCM	1900 mi	Mach 5	Conventional / Nuclear

[123] Missile Defense Project, "DF-26," Missile Threat, Center for Strategic and International Studies, January 8, 2018 last modified August 6, 2021, https://missilethreat.csis.org/missile/dong-feng-26-df-26/.
[124] Missile Defense Project, "DF-31 (Dong Feng-31 / CSS-10)," Missile Threat, Center for Strategic and International Studies, August 12, 2016, last modified August 9, 2021, https://missilethreat.csis.org/missile/df-31/.
[125] "CM-401, Anti-ship Ballistic Missile," Global Security.org, accessed March 8, 2024. https://www.globalsecurity.org/military/world/china/cm-401.htm.
[126] "DF-100 Long Sword-100 – Cruise Missile," Global Security.org, accessed March 8, 2024. https://www.globalsecurity.org/wmd/world/china/df-100.htm

Strategic Stability Concepts and Theories

This section will commence with a general discussion of what strategic stability is and how the U.S. and Russia view strategic stability. Then we will explore the underlying concepts that make up the larger concept of strategic stability which include crisis stability (instability), arms race stability (instability) and deterrence stability. Although the concepts of arms race stability and deterrence stability will be discussed, the greatest focus will be on how HSWs affect crisis stability. The issues described below are indicative of any nation that chooses to develop HSWs. These ideas can also be applied utilizing both conventional and nuclear HSWs, no matter which type a nation determines it will procure.

Strategic stability concerns the extent to which states perceive incentives to start wars, escalate wars already underway, or take actions that risk leading to armed conflict. The lower the incentive to start, escalate, or risk war, the more stable the system. Thus, one objective would be to increase, or at least not undermine, strategic stability. Another objective would be to expand the available tools to engage in competitions in risk-taking and risk-tolerance, otherwise known as brinkmanship.[127]

Strategic stability entails equilibrium, a balance wherein no state has an incentive to start a conflict because of the other side's ability to retaliate. Many times this is discussed as the incentive to use nuclear weapons first, but strategic stability in general does not require the utilization of nuclear weapons. Because we are discussing HSWs which may or may not be nuclear in nature, I will focus on strategic stability in general. Strategic stability may also be

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[127] Heim, *Strategy-Driven Approach*, 9-10.

characterized as the ability of states to avoid escalation and return to a state of equilibrium despite perturbations in the international system such as the emergence of new technologies, threats, crises, or conflicts.[128]

The concept grew out of a logical progression in thinking about the consequences of the nuclear revolution, the challenge of surprise attack, the kinds of targets upon which nuclear weapons might be used, how a nuclear war might be fought, and the requirements of credible deterrence.[129]

Strategic stability is a dynamic phenomenon, focusing on the interactions and incentives of two or more parties. The essential idea of strategic stability came to fruition when defense strategists deliberately imparted what the United States deemed the logical response to vulnerability – to launch nuclear forces upon warning of an enemy's attack – on the Soviet Union. If the United States would be under great pressure to launch its vulnerable forces, the argument ran, then so too, might the Soviet Union.[130] (This theory can be utilized with the first strike capabilities of hypersonic strike weapons.)

The essence of strategic stability is limiting the incentives for states to launch a first strike while at the same time increasing their confidence that they will be able to absorb a first strike and successfully launch a second (or retaliatory) strike. Under those conditions, states will face less pressure during a crisis to escalate a conflict, to respond quickly to incomplete information, or to deploy their forces in a way that might unnecessarily provoke the other side.

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[128] Heather Williams, "Asymmetric Arms Control and Strategic Stability: Scenarios for Limiting Hypersonic Glide Vehicles," *Journal of Strategic Studies* 42. No.6 (2019): 800, DOI:10.1080/01402390.2019.1627521.
[129] Ronald Lehman and Thomas Schelling, "Future Technology and Strategic Stability," in *Strategic Stability: Contending Interpretations,* ed. Elbridge A. Colby and Michael S. Gerson. (Strategic Studies Instigute: US Army War College, 2013), 3, http://www.jstor.org/stable/resrep12086.8.
[130] Lehman and Schelling, "Technology and Strategic Stability," 27-28.

In this manner, strategic stability refers to the likelihood that nuclear weapons will be used intentionally, not accidently, inadvertently, or without authorization.[131]

If deterrence is thought of broadly as the ability to convince an adversary not to attack by threatening either that such an action will be met with intolerable consequences (deterrence by punishment), or that it is ultimately futile (deterrence by denial), the lack of fear of punishment due to missile defense systems necessarily makes a state more willing to escalate and attack. As a result, as long as both adversaries have similar HSW capabilities, they may in fact restore elements of strategic stability as great powers no longer see themselves as immune from retaliation.[132]

Suppose both the United States and Soviet Union had the power to destroy each other's retaliatory forces and society, given the opportunity to administer the opening blow. The situation would then be like the old-fashioned Western Gun duel. It would be extraordinarily risky for one side not to attempt to destroy the other, or to delay so doing, since it not only can emerge unscathed by striking first but this is the sole way it can reasonably hope to emerge at all. As would be expected, such a situation is extremely unstable. On the other hand, if it is clear that the aggressor too will suffer catastrophic damage in the event of his aggression, he then has strong reason not to attack, even though he can administer great damage. A protected retaliatory capability has a stabilizing influence not only deterring rational attack, but also to offering every inducement to both powers to reduce the chance of accidental war. Thus mutual

[131] Gregory Koblentz" Challenges to Strategic Stability," in *Strategic Stability in the Second Nuclear Age,* (Council on Foreign Relations, 2014) 19, http://www.jstor.org/stable/resrep21432.8.
[132] Lee, "China, Russia Hypersonic Programs," 34.

vulnerability was a central ingredient initially to strategic stability – but it was the vulnerability of one's society, not of one's weapons.[133]

Pre-emptive counterforce options and strategic defenses fall under the rubric of damage-limiting capabilities that allow a nuclear power to limit the damage an opponent's strategic nuclear forces can inflict in retaliation. If a state can limit damage through a combination of pre-emptive counterforce and defense to such a degree that striking first is no longer unthinkable, this would be destabilizing. Thus, strategic instability involves a quantitative as well as a qualitative assessment. As an example, if a state can reduce the damage from a retaliatory strike against its homeland by 30% through a combination of counterforce and defense, that state presumably would have little incentive to strike first in a crisis because the damage caused by the remaining 70% in a nuclear war would still be devastating. But a reduction in damage by 95% might provide such an incentive.[134]

The Russian Federation has consistently maintained a wider scope on what leads to strategic stability, arguing that it encompasses more than just nuclear threats and that it is also comprised of the larger military balance. Therefore, capabilities with the potential to undermine a relationship of mutual vulnerability are a threat to stability. A previous example of Russia linking strategic stability to a range of other issues outside of but related to strategic nuclear weapons is exhibited in remarks made by Foreign Minister Sergey Lavrov at the United Nations Conference on Disarmament in 2011: "We insist that there is a clear need to take into account the factors that negatively affect strategic stability, such as plans to place weapons in

[133] Lehman and Schelling, "Technology and Strategic Stability," 31-34.
[134] Wilkening, "Hypersonic Weapons," 133.
[134] Estes, "Framework," 26-27.

outer space, to develop non-nuclear arms strategic offensive weapons, as well as unilateral deployment of a global BMD system."[135] These comments from the Russian Foreign Minister in 2011 may seem a little counterintuitive. The Russians seem to view the United States missile defenses as an attempt to prevent the Russian ability to maintain a second strike capability, when the United States' deterrence strategy proclaims that offensive nuclear weapons deter nuclear weapon states, like Russia and China, and U.S. missile defenses are meant to protect against rogue state threats, like North Korea and, maybe in the future, an Iranian ICBM.[136]

Whether a new technology or weapon system significantly impacts strategic stability depends not only on the intrinsic capacity of that technology or system to do so, but also on whether and how it is deployed and operationalized by different powers and the force structure of the adversaries against which it may be deployed. Certain technologies may be destabilizing in the sense of fostering the use of nuclear weapons in response to their employment, without themselves being first-strike weapons.[137] The Trump administration's Nuclear Posture Review identified a potential link between uncertainty in technology and nuclear posture. This included the potential for unanticipated technological breakthroughs in the application of existing technologies, or the development of completely new technologies, that alter the nature of the threats and the capabilities required to address them adequately. For instance, advancements that would place U.S. nuclear forces or U.S. command and control of those forces in a position that was highly vulnerable to attack would dramatically affect U.S.

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[136] "Fact sheet: U.S. Ballistic Missile Defense," Center for Arms Control and Nonproliferation, last modified June 12, 2023, https://armscontrolcenter.org/fact-sheet-u-s-ballistic-missile-defense/.
[137] Christopher Chyba, "New Technologies and Strategic Stability," *Daedalus* 149 no.2 (2020): 154, doi:10.1162/daed_a_01795.

nuclear force requirements, policy, and posture. The proliferation of highly-lethal biological weapons is another example.[138] Another example may be a cyber-attack on a countries infrastructure after hostilities have commenced that unintendedly removes command and control functions or communications resulting in an escalation to the nuclear threshold. An inadvertent interruption of command and control may be seen as a precursor to a larger attack. This in turn could result in unintended escalation.

There are a few elements that make up the greater concept of strategic stability. These include crisis stability (instability), arms race stability (instability), and deterrence stability. These items are discussed in more detail below.

Crisis Stability (Instability)

Crisis Stability refers to a situation between nuclear powers in which both sides believe their strategic nuclear forces are largely invulnerable, and that they can penetrate any defenses the adversary might construct in sufficient numbers to deter attacks. Both sides believe they can deter their opponent from attacking first in a crisis by assuring devastating retaliation.[139]

Crisis Instability is related to crisis stability and refers to what Thomas C. Schelling called the 'reciprocal fear of surprise attack'. Two types of weapons systems were implicated in crisis instability during the Cold War: counterforce weapons that could destroy a large portion of an opponent's strategic nuclear forces or its strategic nuclear command, control and communication system in a surprise attack; and nationwide air and ballistic-missile defenses,

[138] Mattis, "Nuclear Posture Review," 14.
[139] Wilkening, "Hypersonic Weapons," 136-137.

often called strategic or homeland defenses. Ballistic missiles with short flight times and accurate MIRVs are an example of the first kind of destabilizing weapon. The second kind, nationwide defenses, were thought to be destabilizing if robust enough to intercept a large fraction of the opponent's retaliatory strikes after its retaliatory capability had been degraded by a pre-emptive counterforce attack. Thus, the ABM Treaty did not ban nationwide ballistic-missile defenses altogether but rather limited their size and technical characteristics so they could not effectively blunt a retaliatory strike.[140]

Actions that make nuclear escalation difficult to control constitute another central aspect of crisis instability. Many strategists worried about how to control escalation once the nuclear threshold was crossed because in most scenarios the stakes involved were not commensurate with the destruction inflicted by an all-out nuclear war. By the end of the Cold War, few strategists were confident that escalation could be controlled in a rational manner, and threats to cross the nuclear threshold first were considered those that left something to chance.

The inability to control escalation does not necessarily mean that there are only a small number of options utilizing large numbers of nuclear weapons. In 1974 then Secretary of Defense, James Schlesinger outlined a re-alignment of United States nuclear strike policy which was given the name the "Schlesinger Doctrine" by members in the press. According to Schlesinger, The United States needed the ability, in the event of a nuclear attack, to respond so as to "limit the chances of uncontrolled escalation" and "hit meaningful targets'' without causing widespread collateral damage. The nation's assured destruction force would be

[140] Wilkening, 132-133.

withheld in the hope that the enemy would not attack U.S. cities.[141] This outlined a larger selection of counterforce options against a wide variety of potential adversary actions which was a major change from the earlier Single Integrated Operational Plan (SIOP) which had a very limited number of very large response options in a single strike and focused on the principle of MAD. Although plans were made with a number of smaller nuclear strikes it would still be difficult to control escalation once a strategic attack has occurred. As nations respond to strategic attacks back and forth, they may continue to escalate the conflict in an attempt to affect the calculus of their adversary, ending the conflict on terms that are beneficial to them. As these exchanges continue to occur and increase in magnitude escalation becomes more difficult to control, which could quite possibly lead to all out nuclear war.

Arms Race Stability (Instability)

James M. Acton defines arms race stability as "the absence of perceived or actual incentives to augment a nuclear force ... out of the fear that in a crisis an opponent would gain a meaningful advantage by using nuclear weapons first".[142] Arms race stability holds when the relevant powers have incentives to avoid action-reaction cycles that, in addition to being expensive could also lead to weapon deployments that undermine first-strike stability.[143]

Arms race instability results when one side gains a strategic advantage over its opponent. The more vulnerable side has a strong incentive to modernize its strategic nuclear

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[141] "James, R. Schlesinger," Historical Office, Office of the Secretary of Defense, accessed February 18, 2024, https://history.defense.gov/Multimedia/Biographies/Article-View/Article/571289/james-r-schlesinger/.
[142] James Acton and Thomas Schelling, "Reclaiming Strategic Stability," in *Strategic Stability: Contending Interpretations,* ed. Elbridge A. Colby and Michael S. Gerson. (Strategic Studies Institute: US Army War College, 2013), 121, http://www.jstor.org/stable/resrep12086.7.
[143] Chyba, "New Technologies," 151.

forces, if not to increase their size, to re-establish the effectiveness of its strategic deterrent. Whether this leads to an action-reaction cycle depends on whether the dominant side continues to threaten the opponent's strategic nuclear forces. If so, the dominant side will invest in further damage-limiting capabilities, which then will stimulate the opponent to neutralize them, and so on.[144] This buildup of nuclear weapons by one state and then an increase in production by a competing state in an attempt to catch up and come to some sort of parity is seen by many as a form of nuclear arms race. This build-up of nuclear weapons initially by the United States, followed by a drastic increase in weapons production by the Soviet Union is depicted in figure 3 below.

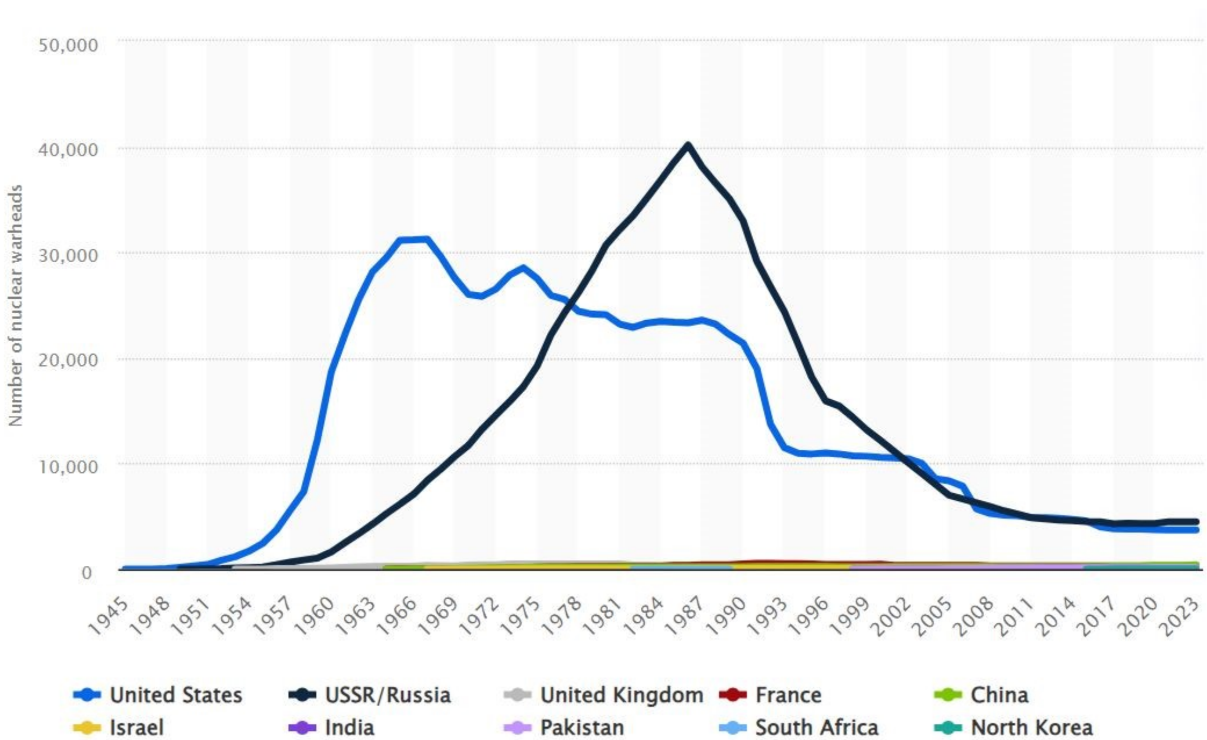

Figure 3. Nuclear Weapons by Country from 1945-2023.

[144] Wilkening, "Hypersonic Weapons," 134

Once multiple nations begin to produce hypersonic weapons at larger numbers, this will stimulate an intense offense-defense competition – which can be seen as a classic form of arms-race instability. This is already starting to occur with U.S. efforts to improve its ballistic-missile defenses in response to Russian and Chinese hypersonic weapons. The United States could invite an offense-defense competition between U.S. hypersonic weapons and Russian and Chinese advanced air defense systems as a cost-imposing strategy that would force them to spend disproportionate sums to improve their air defenses. To the extent hypersonic weapons – ballistic missiles, boost-glide vehicles and cruise missiles – introduce offensive dominance in conventional-strike warfare, reliance on conventional deterrence will be the least unattractive strategy to adopt.[145]

Attempts by the United States to alter its vulnerability to Russian and Chinese nuclear forces (developing hypersonic weapons that could target their nuclear armed capabilities) could be seen as an attempt at developing a first strike capability. This may be seen as destabilizing by Russia or China. When dealing with deterrence by punishment (referring to nuclear deterrence in this instance), mutual vulnerability is necessary. By taking actions that could undermine the Russian and Chinese nuclear deterrent, the U.S. will prompt them to develop new and more advanced weapons which can perpetuate a continuing action-reaction cycle of U.S. missile or missile defense investments and corresponding Russian and Chinese investments. Once technology stabilizes, the end result will be nations remaining vulnerable to each other’s nuclear weapons.

[145] Wilkening, 142.

Deterrence Stability

As previously discussed in the deterrence section, deterrence has two major branches, deterrence by denial and deterrence by punishment. Both can be a factor in deterrence stability as discussed below.

Deterrence by punishment is an influencing strategy whereby threats of the use of force are applied to manipulate the opponent's behavior in such a way that it refrains from taking action that is against your interest. Deterrence stability is often described as a classic balance-of-terror, which is reached when two or more powers are equally capable of inflicting such levels of damage upon each other that it becomes unappealing to initiate an attack.[146] This balance can be shifted through the introduction of offsetting capabilities such as new technologies and doctrines, one of which is the introduction of HSWs. This can be amplified when nations choose to place nuclear warheads on HSWs.

Russia and China have invested heavily in A2/AD capabilities with hypersonic weapons at the center of these capabilities. The U.S., allies and partners do not have the means to counter these capabilities in either the European or Pacific theater. These capabilities provide Russia and China the ability to deter the U.S. through denial. This affects U.S. power projection abilities, making it more difficult to reassure its allies in the region which rely on the U.S. extended deterrent. In the Pacific region the deployment of aircraft carriers and troops becomes more costly (in terms of vulnerability).[147] With the implementation of hypersonic weapons in their respective theaters, Russia and China reinforce their ability to manipulate U.S.

[146] Aarten, "Strategic Stability," 189, Schelling, "Arms and Influence," 19.
[147] Aarten, "Strategic Stability," 189.

behavior. The decreased ability of the U.S. to project power because of the increased A2/AD capabilities of HSWs raises the costs of retaliation against Russian and Chinese regional aggression.

The section above discussed the basic theory of strategic stability to include the specific areas of crisis stability, arms race stability and deterrence stability that may be affected by the introduction of HSWs into competing nation's arsenals. The following section will focus on characteristics of HSWs that could have an impact on the different aspects of strategic stability previously discussed.

Why do Hypersonic Strike Weapons Cause Instability

HSWs have many attributes that can cause instability. The speed and maneuverability of HSWs makes them virtually unstoppable with today's missile defenses. HSWs also decrease the time that a country can classify an attack and then provide a response. Another attribute that HSWs encompass is the ability to remain relatively undetected by radar. According to the United States Missile Defense Advocacy Alliance (MDAA), HSWs (in particular the Tsirkon recently utilized by Russia in Ukraine) are completely covered by a plasma cloud during flight that absorbs radio frequencies and makes the missile invisible to radar. This allows the missile to remain almost undetected on its way to the desired target.[148] The altitude and flight profile of HSWs also make them difficult to detect. This can be seen in figure 4 below that shows the relative difference in detectable range between an HSW and a ballistic missile striking a designated target from the same launch location.

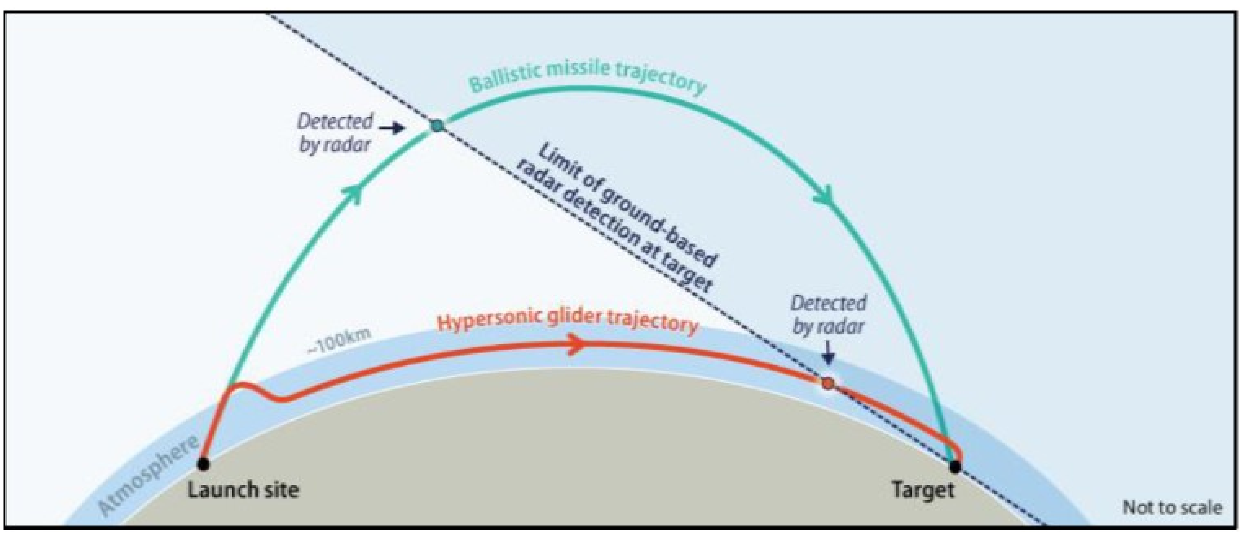

Figure 4. Terrestrial-Based Detection of Ballistic Missile vs. HSW.

[148] Lendon, "Russia Used an Advanced Hypersonic Missile for the First Time in Recent Strike, Ukraine Claims."

These attributes may provide a nation that has HSWs the capability to perform a disarming first strike. HSWs can be conventional or nuclear causing confusion on the type of attack that is underway. Overall HSWs cause multiple types of ambiguity (Target Ambiguity, Destination Ambiguity, and Warhead Ambiguity) that that can lead to strategic instability and will be discussed below.

Speed and Maneuverability

HSWs offer a credible means of targeting an adversary's deterrent with a standoff strike option because of their speed and maneuverability. They have the purported capacity to reach highly mobile targets located deep within an opponent's territory, which had previously been out of reach for most conventional-armed capabilities and – unless one sought to potentially start a nuclear war in the process – for most high speed, high powered nuclear-armed missiles.[149]

Russian hypersonic weapon capabilities are meant for two main audiences: the West and Russia's peripheral nations like Finland, the Baltics, Ukraine, and Georgia. Russian use of HSWs would make locations in Western Europe as vulnerable to strikes initiated from within Russian territory as the Baltics, Ukraine, and Georgia have been in the sub-sonic age. Russia's sub-sonic Kalibr cruise missile, if launched from the Gulf of Finland, could range any country on Russia's western border and would take about two hours to hit Sofia, Bulgaria which is 1200 miles to the south. As an alternative, an air-launched Kinzhal hypersonic glide vehicle traveling Mach 10 could hit Sofia in 11 minutes when launched from the same location. Shifting the firing

[149] Estes, "Framework," 29.

line to Russia's western borders, a Kinzhal could reach London, Paris, or Rome equally quickly. With hypersonic weapon utilization, a target 1200 miles away has the same opportunity for warning as those within roughly 100 miles of a subsonic cruise missile. The Mach 20 Avangard expands the threat umbrella to cover ranges reportedly in excess of 3700 miles with a flight time of around 20 minutes.[150]

Previously it was understood that distance equated to time and thus warning. Russian hypersonic weapons offer a novel way to overcome the tactical depth – the idea of where one's vulnerabilities lie, where those vulnerabilities can be exploited from and how quickly effects can be inflicted. Countries near the Russian periphery are now vulnerable from a wildly increased number of firing locations. For example, sub-sonic munitions would take about 15 minutes to hit Donetsk from the Russian border. Hypersonic weapons with the same flight time could now reach Donetsk from as far away as central (Kinzhal) or eastern (Avangard) Russia.[151]

According to Carrie Lee, Chair of the Department of National Security and Strategy at the U.S. Army War College, "because hypersonics are so fast, and they can take warning systems by surprise, they compress the amount of time between launch and impact." With intercontinental ballistic missiles, it "takes about 26 minutes or so between when you first detect it and when it impacts," but hypersonic missiles might only be detected at the last moment. "There's not a lot of time to make a decision about what a missile is, where it's coming from or investigate if it's a real threat. You have to assume the worst, so that has the

[150] Cummings, "Strategic Goals."
[151] Cummings, "Strategic Goals."

potential to make people trigger happy."[152] Strategically, if an adversary has nuclear armed HSWs, you may have to assume it is a nuclear attack and respond accordingly.

Hypersonic strike weapons drastically shorten the kill chain timeline from launch assessment to weapons impacts. This kill chain timeline risks current nuclear command and control capabilities, thus threatening the ability of the United States to employ nuclear weapons. By reducing the time to respond, the order to execute a response may not be processed prior to weapon impact. These weapons have the potential to increase the risk of entanglement. The premise of entanglement is that the nuclear enterprise relies on various capabilities that support both nuclear and conventional missions. An attack on those capabilities to degrade a nation's conventional capability will also function as an attack on a nation's nuclear capabilities causing an increase in escalation because a nation fears their nuclear capability is threatened.[153] HSWs also increase the risk of rapid conflict escalation or nuclear miscalculation, and lead to an overall degradation in the global security balance.[154]

Hypersonic weapons have the means to alter the current nuclear command, control, and communications (NC3) construct and decision timeline. RAND estimates that ground-based sensors could detect and track a 3000 km range ballistic reentry vehicle 12 minutes prior to impact, while an HGV would only be detected six minutes prior to impact. An HCM would be harder to detect due to its lack of ballistic launch and its ability to be launched closer to a

[152] Rossi, "Global Arms Race."
[153] James Acton, "Why is Nuclear Entanglement So Dangerous?" Carnegie Endowment for International Peace, last modified January, 23, 2019, https://carnegieendowment.org/2019/01/23/why-is-nuclear-entanglement-so-dangerous-pub-78136.
[154] Yohoe et al, "Offensive Leap," 98.

target. An HCM launched 1000 km from the United States could shorten response time from twelve to six minutes.[155]

A decreased assessment to impact timeline would thus necessitate an altered NC3 structure. This shortened command and control timeline could occur with more accurate threat assessment capabilities, semi-autonomous/autonomous analysis, and faster response communications. However, moving to semi-autonomous/autonomous analysis raises many potential issues—including the impact of false positives, risk of cyber exploitation, and rapid conflict escalation. Even with a complete overhaul of the current NC3 system, it is hard to imagine executing a nuclear response option within six minutes of strategic warning. Thus, other options include the delegation of nuclear response or more aggressive nuclear launch posturing. Each of these options would increase the likelihood of an incorrect or errant nuclear execution order.[156] Without the capability to beat the hypersonic strike timeline, the NC3 system is at risk of being struck before they can complete their mission. The current system in which the President maintains sole nuclear command authority creates increased risk that a preemptive hypersonic strike could cause significant delays to, or prevent, the execution of a nuclear response. It also raises the possibility that a hypersonic weapon could strike strategic communication nodes in the NC3 system, preventing the President from communicating a nuclear response to the nuclear forces. This delay would negate the capabilities of the nuclear triad; nuclear capabilities would not need to be destroyed if they can be cut off from the sole execution authority.[157] This will remain a realistic possibility until defensive systems are

[155] Yohoe et al, 99.
[156] Yohoe et al, 99.
[157] Yohoe et al, 100.

developed that are capable of engaging an HSW in a reliable manner. There may be some alternatives to help decrease vulnerabilities such as redundant systems and force dispersal (if possible). Items like this may decrease initial vulnerability, but until there is a viable defense developed, some level of vulnerability will remain.

Hypersonic weapons reduce the amount of time a targeted country has to respond to a strike. During the compressed timeline, a country must first detect a strike, try to fully assess the kinds of weapons involved, debate the appropriate response, distribute any orders for a retaliatory strike, and then see those orders carried out – an exceedingly difficult proposition. The time crunch will increase pressure on decision makers and heighten the risk of inadvertent escalation. With less time to fully understand the nature and scope of the attack, decision makers may veer towards overestimating the attack, especially if they view the very forces their country relies on for retaliation against a first strike to be under imminent threat. A reduction in decision time exacerbates the target and warhead ambiguities problems. Less response time translates to less time to determine whether an incoming hypersonic weapon carries a nuclear or conventional payload and less time to attempt to pinpoint the weapon's final destination.[158]

The compressed time frame in which a state has to react to a potential incoming strike, combined with the introduction of decapitation as a potentially viable strategy, likely reduces strategic stability in important ways. A compressed timeframe requires a state to take precautionary measures so that it retains the ability to reserve sufficient nuclear weapons to launch a second strike. For the United States' nuclear triad, this means keeping forces on a heightened state of alert similar to protocols set in place during the cold war, and possibly

[158] Bugos and Reif, "Understanding Hypersonic Weapons," 17. Chyba, "New Technologies," 156.

increasing threat levels. For states with smaller nuclear arsenals, this could result in a series of changes to command and control that ultimately inject yet more risk into the regional or international environment. Current land-based missiles are able to launch within five minutes of a presidential order, but the time between when a missile is launched and when a leader receives word, then makes a decision, could be considerably longer. As a result, many countries, including the United States might face incentives to give launch authority to military commanders at much lower levels, again increasing risk.[159] The probability of this occurring in the United States is very low, but other nations may be more likely to put measures such as this into effect.

These operational adjustments could then negatively impact strategic stability in three ways. First, the risk of accidently deploying or using a nuclear weapon increases. 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 happen, as multiple did during the Cold War. As an example, in May 1957, an aircraft was ferrying a weapon from Texas to New Mexico. While approaching Kirtland AFB in NM the weapon dropped from the bomb bay approximately 4.5 miles south of Kirtland AFB detonating the high explosive material and destroying the bomb displacing fragments as far as a mile from the impact point.[160] This is only one example of many that took place during the cold war and will likely happen again if weapons are placed on extended alerts or deployments. Second, it increases the potential for inadvertent escalation as adversaries may misinterpret actions as

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[159] Lee, "China, Russia Hypersonic Programs," 32.
[160] "Broken Arrows: Nuclear Weapons Accidents," Atomic Archive, accessed October 18, 2023, https://www.atomicarchive.com/almanac/broken-arrows/index.html.

aggressive, escalatory, or preparatory for war when in fact they are simply a reflection of appropriate force posture given the compressed decision-making timeframe – a classic security dilemma with potential for escalation. Third, the compressed timeline alters the incentives of decision-makers in ways that encourage a leader to "shoot first and ask questions alter." 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 timeframe generously estimated at a quarter of what it is now, leaders will have little choice but to adopt a "launch on warning" posture that leaves little room for error.[161] Until active and passive measures are developed that can deal with the increased capabilities of HSWs, the above discussion on HSWs requiring changes in posture will remain an issue.

The concerns addressed during the previous discussion on speed and maneuverability of HSWs connects directly into the next section of how HSWs can be seen as having a first strike capability, causing stability concerns.

First Strike Capability

HSWs, maneuverable and able to travel at greater than 5 times the speed of sound, could allow states to conduct low – or no – warning attacks and evade missile defenses. These weapons could also execute large-scale, nonnuclear strategic attacks, the rate of speed compressing the decision-making time leaders have to respond to such attacks.[162]

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[161] Lee, "China, Russia Hypersonic Programs," 32-33.
[162] Matthew Kroening, "Will Emerging Technologies Cause Nuclear War?: Bringing Geopolitics Back In," *Strategic Studies Quarterly* 15, no. 4 (2021): 65-66.

The speed and precision of hypersonic weapons (and the lack of defenses against them) continue to add the possible alternative of an unprovoked first strike. Such developments are fundamentally destabilizing because they invite pre-emptive strategies, launch-on-warning policies and encourage a dynamic in which competitors continue to seek ways to offset each other's capabilities.[163]

Increased maneuverability, combined with the speed at which hypersonic weapons travel, may also introduce decapitation as a viable strategy, which may further destabilize strategic security on the international stage. While most states already struggle with ensuring that lines of command and control remain viable in the event of a major nuclear strike, systems that work to preserve the survivability of the serving executive would be left with little to no advanced warning, and no ability to determine *ex ante* where a missile might hit. As a result, hypersonic weapons substantially increase the risk of a first strike and increase the probability that first strike would be successful, thereby increasing incentives for great powers to pursue such strikes. In countries with defined protocols and procedures for the orderly transition of power, this may not present a particular problem. However, regimes that concentrate power at the top with a single person or family without a clear line of succession, or what we might call personalist regimes, examples of which would be China and North Korea, may be more vulnerable.[164]

Hypersonic weapons are particularly useful in the early stages of a conflict, when they can neutralize an opponent's high-value targets, including air defense radars, fighter bases,

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[163] Aarten, "Strategic Stability," 191.
[164] Lee, "China, Russia Hypersonic Programs," 35.

missile batteries, and command-and-control facilities. Because these same facilities may be tied into a nuclear-armed country's nuclear warning and command systems, strikes against them could be interpreted by the target state as the prelude to a disarming first strike and trigger the early use of its own nuclear weapons.[165]

Certain attributes are required for an effective first strike scenario to take place. Sufficient numbers of HSWs can meet these requirements as described: (1) Accurate Delivery: "The precision needed to hold adversary assets at risk while minimizing unintended effects"; conventional HSWs will be very accurate with a small circular error probable (CEP). (2) Penetrating: "The capacity to counter active and passive defenses, including hardened and buried facilities, to pose credible deterrent threats and achieve military objectives with high confidence;" HSWs are able to defeat current defense systems to reach desired targets. (3) Diverse and Graduated Options: The ability to provide "the spectrum of yield options, weapon types, and delivery options necessary to support the most effective tailoring of strategies across a range of adversaries and contingencies."[166] HSWs are capable of being launched from multiple types of platforms and carry nuclear or conventional warheads, making them very diverse.

As discussed above first strike capabilities can be considerably destabilizing. The following section discussing target ambiguity follows that if a strike is occurring and it is not possible to determine the target of the attack may also be quite destabilizing.

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[165] Klare, "Arms Race," 6-7.

[166] U.S. Department of Defense, *National Defense Strategy of the United States of America, Including the 2022 Nuclear Posture Review and the 2022 Missile Defense Review,* (Washington, DC: DOD), October 2022, 44, https://apps.dtic.mil/sti/trecms/pdf/AD1183514.pdf. Russell et al, "No First Nukes," 144.

Target Ambiguity

Increased maneuverability also means that states have less time to determine whether a strike is intended to hit a nuclear target or not, if at all. This matters because different targets have different values (and signals) associated with them. Targeting conventional capabilities versus nuclear command and control, for example, sends a very different signal to a receiving state. Targeting of nuclear command and control could be seen as initiating a strategic attack, or an attack against a nation's strategic forces. Degraded command and control capabilities affect a state's ability to further defend itself, and may signal a wider intent to escalate. Targeting purely conventional sites, on the other hand may signal a desire to prevent escalation. When a receiving state is unable to determine which type of site an adversary is targeting, it will almost certainly be forced to assume the worst case. If a state believes that an incoming missile is intended to disrupt its ability to launch a second strike, leaders may believe that they have been placed in a "use it or lose it" situation. They then may face strong incentives to launch their own nuclear arsenal before it has the chance of being destroyed in a first strike.[167]

The speed and maneuverability of the missile further complicates the dilemmas presented by the ambiguous nature of hypersonic weapons. The characteristics of the missile itself introduce target ambiguity. This means that hypersonic weapons introduce even more uncertainty into leaders' decision making because leaders are unable to determine an expected target until very late. As a result, leaders cannot know until a missile impacts whether it is aimed at a minor target or a major command and control system. Leaders may also assume the

[167] Lee, "China, Russia Hypersonic Programs," 35.

worst about a target in order to preserve second strike capability. This means that even a conventional payload on a hypersonic weapon targeting a terrorist cell has the possibility of being interpreted as a nuclear assault on a great power's nuclear command and control system. This set of assumptions runs a great risk of inadvertent escalation, and could significantly decrease strategic stability.[168]

A problem with target ambiguity arises when conventional- and nuclear-delivery systems or command-and-control systems are commingled at the same site and / or utilize the same equipment. Attacking such sites could blur the distinction between conventional and nuclear war. This increases the chance that the attack will be misperceived as an attempt to degrade a country's nuclear, as opposed to conventional military forces.[169]

The nuclear and conventional command-and-control systems of the major powers may be interconnected, or entangled, making it difficult to differentiate one from another when initiating an attack. Therefore, any attack on command-and-control facilities at the onset of crisis could be interpreted by the defender as a prelude to a nuclear rather than conventional attack causing the defender to launch its own nuclear weapons before they are destroyed by an anticipated barrage of enemy bombs and missiles.[170]

Target ambiguity as discussed above can be seen as very similar to the next topic of destination ambiguity. One of the main distinctions is that with target ambiguity, the target that is struck is known, but the reason for striking the target may not be, is this a possible escalation? Regarding destination ambiguity, the intended location of the strike may not be

[168] Lee, "China, Russia Hypersonic Programs," 38.
[169] Wilkening, "Hypersonic Weapons," 140.
[170] Klare, "Arms Race," 11.

known. This could mean even the intended nation that will be struck may be unknown until weapons begin to impact, discussed in the next section.

Destination Ambiguity

Destination Ambiguity is the inability to determine the expected impact location of a weapon system based on known information of launch and flight characteristics. HSW maneuverability and unique flight paths can cause destination ambiguity. The potential miscalculation due to the maneuverable nature of hypersonic systems, has implications for the United States, Russia, and China. This feature has been identified as possibly destabilizing because of potential difficulty in identifying the vehicle's intended location of impact. This uncertainty "complicates national defense mechanisms and response options, both nationally and internationally," because it is plausible even the intended recipient's neighbors may not be able to discern if it's headed for them or their neighbor depending on its direction. Combine this with its high speed of travel and we have another example of the potential disruption and compression in the respondent's decision-making cycle.[171]

The maneuverability of HGVs is the most common characteristic cited for their ability to cause vulnerability. General Paul Selva, Vice Chairman of the Joint Chiefs of Staff, was quoted in 2019 as saying, "The best layman's description I've heard of hypersonics as a strategic threat goes something like this: If you are going Mach 13 at the very northern edge of Hudson Bay, you have enough residual velocity to hit all 48 of the Continental United States … You can

[171] Estes, "Framework," 34.

choose… to make a right or left turn and hit Maine or Alaska, or you can hit San Diego or Key West. That's a monstrous problem"[172]

Warhead Ambiguity

Hypersonic weapons have the capacity to deliver both nuclear and conventional warheads. This dual capability (which James Acton has labeled "warhead ambiguity") has the potential to lead to inadvertent escalation and conflict spirals from which states cannot recover. According to current U.S. policy, HSWs will only be used to deliver conventional payloads. By contrast, both China and Russia have announced their intention to use hypersonic weapons to modernize their nuclear forces. These conflicting policies and the ease with which they can change introduce additional uncertainty into leaders' decision-making when trying to decide whether an incoming strike will be nuclear or not.[173]

Conventional strikes signal very different intentions from nuclear strikes. Warhead ambiguity introduces uncertainty into decision-making because leaders are unable to tell the difference between a conventional and nuclear strike until it is too late. Leaders may be forced to assume the worst – that any incoming strike using a hypersonic missile is nuclear in nature. Nuclear strikes signal a far more serious exchange, and in many cases are considered a prelude to total war. By being forced to assume that any hypersonic weapon is carrying a nuclear payload, the risks of escalation increase significantly.[174]

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[172] Rachel Cohen, "Hypersonic Weapons: Strategic Asset or Tactical Tool?" *Air and Space Forces Magazine*, May 7, 2019, https://www.airandspaceforces.com/Hypersonic-Weapons-Strategic-Asset-or-Tactical-Tool/. Ivan Olerich, "Cool Your Jets: Some Perspectives on the Hyping of Hypersonic Weapons," *Journal of the Atomic Schentists,* 76, no.1, 40, DOI: 10.1080/00963402.2019.1701283.
[173] Bhide, "Strategic Drivers," 76, Lee, "China, Russia Hypersonic Programs," 37.
[174] Lee, "China, Russia Hypersonic Programs," 338.

Ambiguity about whether a hypersonic weapon is carrying a conventional or nuclear payload could trigger a nuclear-armed country, targeted by conventional attack, to launch its nuclear weapons in response. The risk warhead ambiguity poses to stability is most imperative when a country fields nuclear and conventional variants of the same missile. China and Russia are deploying such dual-capable missiles, including HGVs and HCMs. The use of such weapons in a great-power conflict could readily lead to inadvertent escalation.[175]

The previous chapter discussed some reasons why HSWs may cause instabilities. These included the increased capabilities of HSWs of greater speed and maneuverability over current weapon systems, which results in the ability to all but render current missile defenses impractical. These capabilities lead to many concerns including the possibility of an adversary launching a first strike, the ambiguity of not knowing what target (target ambiguity) the weapon will strike, the ambiguity of not knowing where the weapon is going (destination ambiguity) and the ambiguity knowing whether the weapon is nuclear or conventional (warhead ambiguity). These are currently concerns when dealing with HSWs with relation to today's missile defenses. Many of these issues may be conquered in the future with the advent of more capable missile defenses. The above discussion relates HSW implementation to missile defenses and early warning systems that are currently fielded. The following chapter will discuss some of the strategic implications that may be caused by the previously discussed issues resulting from the fielding of HSWs.

[175] Bugos and Reif, "Understanding Hypersonic Weapons," 16.

Strategic Implications

Hypersonic weapons will blur the distinction between conventional and nuclear deterrence. Missiles launched from the territory of a nuclear weapons state very easily could be assumed to be nuclear-armed, especially if the political stakes at issue are vital interests. Highly accurate long-range conventional HGV weapons also pose a threat to the nuclear retaliatory forces of an adversary, which incentivizes first-strike fears and the desire to see nuclear weapons as a "use it or lose it" weapon. Although the collateral damage attendant from conventional, compared to nuclear weapons is less, accuracies sufficient to disable enemy land-based missiles deployed in fixed locations, including silos, will not be impossible to impose. The possibility of conventional and/or nuclear HGV weapon attacks will increase a states' interest in missile defenses and mobile land-based missiles.[176]

The three ambiguities, (warhead, destination and target) together independently undermine strategic stability because of the uncertainty they pose for how a potential adversary should respond to interpret a weapons launch while crisis stability depends on ensuring two competitive actors do not have an incentive to strike first. If nuclear weapons can be eliminated by a hypersonic weapons strike, then the receiving end of a strike may conclude that it no longer has a survivable second-strike capability with the advent of hypersonic weapons, thus decreasing crisis stability. China maintains a no first-use nuclear policy, but this may be threatened by U.S hypersonic weapons capabilities.[177] The development and fielding of

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[176] Cimbala and Lowther, "Comparative Strategy," 286.
[177] Bhide, "Strategic Drivers," 85.

U.S. HSWs may prompt China to adjust current nuclear weapon policy allowing the use of nuclear weapons – even in a limited or theater extent – to pre-empt the possibility of the U.S. using hypersonic weapons in an attempt at eliminating the Chinese nuclear arsenal.[178]

A possible way to defeat a nation's HSWs would be to take out the space-based assets they use as guidance. Because it is difficult to target the delivery vehicle itself with current missile defenses, there is strategic rationale in instead targeting their space-based guidance systems in order to disrupt their flight path. Such a decision may disrupt the HSW owner's signaling and communications to other military assets unless the space-based asset is solely assigned to the hypersonic capabilities. An attack on these assets may interrupt things like intelligence and reconnaissance assets or legs of its strategic forces, raising the risk of miscalculation and/or escalation. This kind of an attack may also cause potential consequences such as blinding an opponent's early warning capability or rendering part of their forces nonfunctional thus encouraging an escalatory response.[179]

There is the possibility that hypersonic missiles armed with conventional warheads might be viewed as more usable than their nuclear-armed counterparts or other nuclear systems. This could include employment against strategic assets and their infrastructure, because HSWs are seen as less escalatory and could be used as a possible method of damage control. Moscow has been open about its concerns that U.S. conventionally-armed HSWs may offer an appealing way to target their nuclear forces and C3 without actually crossing the nuclear threshold. This could subsequently place the burden of nuclear escalation on Russia.[180]

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[178] Bhide, "Strategic Drivers," 85, Sugden, "Disruptive Effects," 13.
[179] Estes, "Framework" 31.
[180] Estes, 31-32.

The above mentioned issue has raised debate among Russian officials about what would be a proportional and credible response. Some may see that threatening a nuclear response to a nonnuclear attack would be seen as a credible and hopefully deter the United States.[181]

The ability of HGVs to bypass current missile defense systems eliminates the survivability such defenses are intended to secure. The possibility of U.S. HGVs penetrating Russian defenses undermines crisis stability between the two states as an asymmetrical HGV may incentivize a first strike, while a conventional U.S. HGV may increase the U.S. nuclear threshold as it represents a conventional option that may otherwise be achieved by a tactical nuclear weapon. This may look like a good idea from the U.S. perspective, however, the threat of a U.S. HGV may indeed lower a potential adversary's nuclear threshold in an attempt to offset the potential U.S. advantage.[182]

Russia and China see U.S. plans to deploy highly precise conventional hypersonic missiles as a U.S. attempt to possibly cripple their nuclear retaliatory capabilities. A perception that hypersonic weapons could prove decisive in a military conflict is shaping the strategic posture of both Russia and China. The 2014 Russian Military Doctrine regards the deployment of strategic non-nuclear systems of high-precision weapons [hypersonics] as a military threat, and a risk to their deterrent capability. The doctrine considers conventional hypersonic weapons (or strategic non-nuclear high-precision weapons) to be equivalent to nuclear weapons in terms of their implications for deterrence. According to the doctrine, "within the framework of strategic deterrence measures of a forceful nature the use of high-precision

[181] Estes, 31-32.
[182] Bhide, "Strategic Drivers," 85.

weapons is envisaged by the Russian Federation."[183] President Vladimir Putin in his annual Presidential Address to the Federal Assembly in 2013 stated "The ramping up of high-precision strategic non-nuclear systems by other countries, in combination with the build-up of missile defense capabilities, could negate all previous agreements on the limitation and reduction of strategic nuclear weapons, and disrupt the strategic balance of power."[184] The development and deployment of U.S. HSWs may be seen by Russia as a reason to increase their nuclear stockpile, or change the posture of their nuclear forces.

The Chinese government shares the Russian view that hypersonic systems will pose a threat to opponents' nuclear forces. In the *2013 Science of Military Strategy* the Chinese Academy of Military Science argues that U.S. CPGS weapons could force China into a "disadvantaged, passive position" by weakening the Chinese nuclear counterstrike capability. A large U.S. hypersonic arsenal would undermine the Chinese nuclear deterrence capability. It is also reported that China is worried about the potential combination of high-precision warhead delivery methods with low-yield nuclear warheads. Weapons of this nature could be seen as "tactically usable". The U.S. decision to place BMD and radar systems in the Asia-Pacific region is also a driver for Chinese concern about hypersonic weapons. These factors are contributing to the Chinese decision to raise the alert of nuclear forces and build a launch-on-warning capability.[185]

Chinese and Russian strategic hypersonic systems are being designed as dual warhead capable. This raises the problem of a target nation being able to reliably distinguish between an

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[183] Frigoli, "Implications," 15.
[184] Vladimir Putin, *Presidential Address to the Federal Assembly,* December 12, 2013, The Kremlin, Moscow.
[185] Frigoli, "Implications," 16.

incoming conventional strike and a potential nuclear strike once HSWs are launched. This is one reason why ambiguity has raised concerns about Chinese anti-ship ballistic missiles. There is a potential risk that a conventional ballistic missile strike against U.S. surface assets or bases in the Pacific theater could lead the U.S. command system to assume the worst and respond in kind. Ultimately, decisions about the nature of an incoming strike will revolve around what can be discerned about the physical properties of the detected contact. If they are consistent with the signature of a nuclear weapon delivery system, then a nuclear response would likely be considered. This is one of the main reasons dual capable systems cause instability. U.S. naval strategist Norman Friedman described the risks very simply: 'nuclear-armed nations shouldn't throw ballistic missiles at each other'. HSWs that further reduce warning times can only heighten those risks.[186] As nations continue to develop dual capable HSWs, placing both conventional and nuclear in the same locations, the ambiguities discussed in the previous section may continue to be exaggerated causing decreases in stability between nuclear capable nations.

Nuclear capable hypersonic cruise weapons with intermediate ranges (500-5000 kilometers) also raise strategic stability issues. Although these are not new problems with missiles of this range, technology exacerbates some of them. During the Cold War, moves by both NATO and the U.S.S.R. to position short- and intermediate- range nuclear weapon delivery systems near the borders of the other proved to be destabilizing. While the U.S. was placing intermediate-range nuclear forces in Europe, Russia decided to place missiles in Cuba. This highlighted the need for the negotiation of the Intermediate-Range Nuclear Forces Treaty (INF).

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[186] Davies, "Hypersonic Weapons," 12.

This treaty followed a period of deployment of American and Russian intermediate-range nuclear ballistic missiles. Hypersonic cruise weapons on much flatter trajectories will compress decision making time frames, possibly decreasing stability like the intermediate range nuclear missiles have done in the past.[187]

There is a broadening gap in military ability with the proliferation of hypersonic weapons. A weapon with no known defense may entice a subsequent arms race and stockpiling. A nation with a sizeable advantage in this arena is likely to be searching for the ideal time to execute a first strike against an adversary. The lack of defenses, reduced warning and reaction timeline, inexact ability to determine enemy weapon type, and inability to determine a designated target could force a more responsive defensive posture. Delegation of command and control may result in a “launch on warning” order, like that of the cold war which, more than once, brought the world to the brink of catastrophe.[188] One of the most notable incidents was during exercise the U.S. exercise Able Archer in November 1983, in which the U.S.S.R. perceived the exercise as a ruse of war and almost launched a preemptive attack on the U.S. The decision to not launch an attack was made by a person in the loop of the decision making process in Russia. If we look to increase automation in capabilities and start to remove the ‘man in the loop’ the possibility of inadvertent escalation increases.

Advancement in hypersonic weapons will no doubt provoke developments in other technologies. Space-based defenses may take better advantage of limited flight time, but the development of space assets may lead to other issues such as a proliferation of counter-space

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[187] Davies, “Hypersonic Weapons,” 12.
[188] Powell et all “Hypersonic Weapon Threat,” 134.

weapons that jeopardize other interests. The short warning times may eventually call for automated interceptor systems to a degree not previously acceptable, up to and including firing without human approval. As stated above, removing the ‘man in the loop’ of critical decision making regarding responses to include the utilization of nuclear weapons may lead to inadvertent escalation that could have been avoided.

When confronted with the exceptionally challenging post-launch problems described above, HSWs may increase the attractiveness of pre-emptive attacks to make sure they are neutralized prior to the escalation of hostilities.

Another issue will be the proliferation of HSWs as the technology matures. Russia and/or China could increase their revenue by selling export versions of these systems to current customers like India, Syria, or Turkey. This may provide them the added benefit of complicating the United States’ strategic landscape having a larger number of nations with access to HSWs which could escalate conflicts the U.S. may not initially be involved in. Perhaps most concerning would be the sale of a limited quantity of hypersonic weapons to a Western Hemisphere nation like Venezuela or Cuba.[189] Russia or China may find strategic value in placing HSWs on America’s doorstep, adding complexity to already uneasy relationships.

After looking at the tennents of strategic stability and some of ways HSWs may cause instability, some possibilities that may decrease some of the instability caused by HSWs will be discussed.

[189] Cummings, “Strategic Goals.”

What Can Be Done About It

As discussed above, the implementation of HSWs may lead to a decrease in stability between nuclear weapon states. The section below will describe a few things that might be able to decrease the instabilities described above.

States often pursue costly new military technologies due to uncertainty and 'a constant fear on either side that the other has developed a dominant position, or will do so, or will fear the first to do so with the resulting danger of premeditated or pre-emptive attack. Arms control can contribute to arms race stability by placing reciprocal limits on capabilities, increasing transparency into an adversaries' actual capabilities and force posture, thus reducing the likelihood of success in the event of military adventurism.[190] In order for arms control to work, there would have to be a verification regime put in place like those previously utilized during the nuclear arms treaties START and NEW START.

Strategies that might complicate the "fog of war" should be examined. Although preemptive strikes with hypersonic weapons against command, control, and communication centers might be a useful way to counter anti-access / area denial capabilities, they also risk "blinding" and confusing an adversary's leadership. This may cause decision makers to mistakenly believe a nuclear strike is underway. This represents a serious risk of inadvertent escalation.[191] Any strategy that blurs the line between conventional and nuclear warfare should

[190] Williams, "Asymmetric Arms Control," 792.
[191] Zhao, "Going Too Fast," 7.

be thoroughly scrutinized to determine how the adversary may react and if the projected benefit outweighs the possibility of misconception and inadvertent escalation.

When nations choose to arm HSWs with nuclear warheads, there has to be a way to differentiate which HSWs are going to be nuclear and which will remain conventional. It could possibly be a difference in weapon type that would allow for an adversary to discriminate what type of HSW was launched. It could also be a difference in location similar to the U.S. missile defense system today. By segregating nuclear missile locations from conventional missile locations, adversaries should be able to discern what is being launched and then respond appropriately.

The pursuit of hypersonic arms control is increasingly important as these weapons transition from an ‘emerging technology’ and are deployed in greater numbers and on more diverse delivery platforms. Chinese and Russian hypersonic weapons are already fielded, and the United States plans to begin deploying its own hypersonic capabilities in the near future. As these weapons systems are fielded it may be beneficial to pursue arms control agreements. If this is to be beneficial the agreements would have to be trilateral between The U.S., Russia and China. If bilateral agreements were made between only two of the three nations, it would leave the third open to gain a possible advantage.

Reciprocal transparency measures could be helpful. These might include data exchanges designed to build confidence in the survivability of land-based nuclear assets and early-warning radars and C3I capabilities. Additional reciprocal measures might include sharing information about “red lines” to reduce escalatory risks, and exchanging assurances that early warning radars and satellites will not be targeted. Without a reliable verification mechanism for clarifying the nature of the warheads carried by hypersonic missiles, warhead ambiguity is likely to continue to pose a major challenge to threat perceptions, and a potential source for miscalculation, both in peacetime and after the outbreak of conflict.[192] Although a verification regime would be beneficial, with the current state of affairs with the U.S. withdrawing from the INF treaty and the NEW START Treaty expiring soon, the possibilities of developing a verification regime in the current state of affairs would be challenging and would need to include the United States, Russia and China.

Current authority to employ nuclear weapons lies either with the president alone or with a circle of senior decision makers in each great power nation. If rapid response efforts are made against hypersonic nuclear weapons, the possibility exists to delegate that authority below the current necessary level, which could further increase crisis instability, possibly allowing for an inadvertent increase in escalation once hostilities were to commence. Nations must be transparent on where the authority lies to employ nuclear weapons so all participants are aware of the possibility of escalation from lower level. Advances in automation and artificial intelligence (AI) should be leveraged for earlier identification. Quicker identification of the severity of an attack will allow more time for decision makers to determine the most appropriate way to respond.

In the near future HSWs very well may cause instabilities as described in the previous sections. Although there is a good chance of instability increasing, there are some things that may be done to help mitigate these instabilities that were discussed above. The following

[192] Frigoli, "Implications," 17-18.

section will discuss some possible policy recommendations for the U.S. when implementing HSWs.

Policy Recommendations

The United States must reconsider the current policy prohibiting the placement of nuclear weapons on hypersonic vehicles. If the near peer adversaries of Russia and China will be arming their HSWs with nuclear weapons, it is only expected that they will believe the U.S. is doing this also, even when stating that they won't. By doing this, the U.S. will have more possibilities for responses in the event of conflict. This may lead an adversary to pause and reevaluate an attack if they know for certain that nuclear HSWs are a possible response to any escalation and attack.

In parallel the United States needs to develop a comprehensive hypersonic strategic plan, and continue its antiballistic missile defense systems advancement. This advancement must include the capability to defend against near-peer nuclear-armed hypersonic glide and boost-glide vehicles. The U.S. must also continue to invest in multiple forms of hypersonic defense. Hypersonic missile defenses are critical in minimizing the capability of China and Russia to hold U.S. targets at risk. Kinetic Kill vehicles (KKVs) are the current anti-ballistic missile defense method. Hypersonic weapons' high-maneuverability renders KKVs ineffective for destroying HSWs. KKVs launched in succession may be able to force an HGV to change its trajectory or even force the HGV to take a trajectory which moves it away from its intended target. This may be an effective interim defense against a conventional HSW. Jamming – with long-range ground-based technologies or airborne platforms – may offer viable long-term defenses against HGVs. Long term defense development will also need to explore directed energy methods for missile defense and HGV elimination, and exploration into multi-domain anti-HGV methods is a critical requirement for future defenses.[193] According to the 2022 Missile Defense Review, the United States will continue to develop active and passive defenses against regional hypersonic missile threats, and pursue a persistent and resilient sensor network to characterize and track all hypersonic threats, improve attribution, and enable engagement. The United States will also pursue joint research and development on hypersonic defense programs with key allies and partners.[194]

The U.S. will also need to simultaneously engage both Russia and China in the establishment of bilateral or trilateral agreements to address and mitigate what is likely to become an iterative series of countermoves by all parties involved.[195] If bilateral agreements are to be made, they will have to be made with both Russia and China separately, ensuring that one nation is not left alone to unilaterally increase capabilities while the other two remain limited.

The U.S. needs to determine and explicitly communicate the role it envisions for its hypersonic weapons. There are three possible options for U.S. HSWs. The U.S. could pursue a nuclear-only option, which would posture the U.S. to only use nuclear warheads on its hypersonic delivery vehicles. This would eliminate the question of warhead ambiguity and offer the U.S. a means of penetrating current missile defenses. Crisis stability, target ambiguity, and destination ambiguity will each remain substantial concerns with the nuclear-only option, potentially undermining strategic stability. The other nuclear option – dual use – is the most destabilizing option as it conflicts with earlier official U.S. statements regarding the weapons

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[193] Bhide, “Strategic Drivers,” 87.
[194] Department of Defense, *2022 Missile Defense Review,* 7.
[195] Wiener et al, “Impact on Deterrence,” 159-160.

and perpetuates the warhead, target, and destination ambiguities.[196] If other nations continue to pursue dual capable HSWs, the U.S. will need to continue down this path. The third option is to maintain conventional only HSWs as the U.S. has currently stated. Destination and target ambiguity remain, but this should take care of warhead ambiguity as long as other nations 'believe' the U.S. claims.

In the interim, while defenses against HSWs are being developed, there are some things that can be done in order to help decrease instabilities caused by HSW development and implementation. The U.S. needs to ensure that there are capable and redundant C2 systems, making a first strike less likely to succeed. Dispersing response capabilities to multiple locations, within the United States and among allied nations, will assist in decreasing the likely success of an adversarial decapitating strike. The visible movement of capabilities will increase the variables required in an adversary's decision calculus, which should help to increase stability.

[196] Bhide, "Strategic Drivers," 87-88.

Conclusion

Hypersonic weapons, if deployed in large numbers and based on a variety of launchers, can alter the prevailing model of deterrence stability by raising uncertainty about the survivability of nuclear retaliatory forces and NC3 systems. They can do this by shortening the expected time available for decision makers to process through the detect–decide–direct process. The proliferation of medium and longer range conventional hypersonic weapons may also appeal to states to increase their military power in support of deterrence by denial, as opposed to deterrence by threat of retaliatory punishment. Nuclear weapons states equipped with long-range conventional hypersonic weapons can easily cross the nuclear threshold by a mistaken decision that conventional deterrence to include hypersonic weapons was infallible.[197]

HSWs will decrease the time available to American senior leadership in a future nuclear attack. Time compression is changing the risk-reward calculation of United States adversaries. Nuclear [Strategic] deterrence creates stability and depends on an adversary's perception that it cannot complete a successful first strike, prevent a guaranteed second strike, or prevent the United States from effectively commanding and controlling its nuclear forces at any time during a conflict. That perception begins with an assured ability of the United States to detect, decide and direct a second strike within the reduced time lines due to the development of new technologies such as hypersonic weapons.[198] As more hypersonic weapons are fielded, the

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[197] Cimbala and Lowther, "Comparative Strategy," 292.
[198] 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/.

ability of nations to conduct a decapitating strike on both sides may increase. This may lead to the different types of instability that were discussed in the previous chapters.

Tactical hypersonic weapons (stand-off strike weapons) will challenge existing ship-borne missile defense systems even more than ballistic missiles – potentially to the point of rendering defenses largely ineffective. A new class of intermediate-range weapons in the form of hypersonic cruise missiles, some of which will be nuclear capable could proliferate with concomitant risks to strategic stability. In the not-too-distant future there will be multiple countries with the capability of orbiting prompt strike systems that can deliver a prompt strike anywhere on the world's surface with significantly less warning time than is currently the case with long-range ballistic missiles.[199] All of the above mentioned issues may cause nations to become more offensively minded, resulting in the development of first strike plans utilizing the new HSW technologies. This may cause a period of instability until nations are able to increase the capability of defensive systems.

Hypersonic Strike Weapons are already available in some nations' arsenals and will continue to be developed by other nations, both ally and adversary. They are similar to nuclear weapons in the fact that once the technology is out there, it cannot be undone. The United States needs to continue to develop HSWs and expand defense plans to employ HSWs in deterrent postures toward adversaries on all levels from near peer (Russia, China) to regional (North Korea, Iran) and even non-state actors such as ISIS and Hamas. By doing this the U.S. will continue to remain on a level playing field with near peer adversaries and be able to adapt to situations caused by non-state actors in the years to come.

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[199] Davies, "Hypersonic Weapons," 13.

When dealing with HSWs, there are steps that the United States can take to help alleviate some of the future instabilities. The United States must consider placing nuclear weapons on hypersonic vehicles which would counter adversaries that are already doing this, allowing a more diverse set of capabilities for decision makers. Defensive capabilities must continue evolving. This will need to include increasing the capabilities of current missile defenses and developing new technologies such as directed energy systems and jammers capable of disrupting HSWs in flight. The U.S. will need to engage Russia and China, explicitly communicating the role envisioned for U.S. hypersonic weapons. This will leave less room for ambiguity in the event of conflict.

The U.S. needs to ensure that there are capable and redundant C2 systems, making a first strike less likely to succeed. Dispersing response capabilities to multiple locations, within the United States and among allied nations, will assist in decreasing the likely success of an adversarial decapitating strike. Implementation of some of the above mentioned concepts may decrease the initial instability caused by adversarial hypersonic fielding until the U.S. is able to field HSWs and the associated increased missile defense capabilities.

With the already ongoing race to build and field HSWs, there will be a period of instability created as nations field these weapons ahead of their competitors and ahead of defensive capabilities. As the first nation succeeds to field a new weapon system gains a strategic advantage over its competitors, the strategic environment will continue to become more unstable. There are some steps that can be taken as mentioned above to assist in decreasing the instability until other nations are able to field their own HSWs or defenses capable of neutralizing the emerging hypersonic threat.

Bibliography

Aarten, Sander Ruben. *The Impact of Hypersonic Missiles on Strategic Stability: Rusia, China and the US.* Militaire Spectator, Jaargang 189 Nummer 4, 2020: 182-193

Acton, James. “Why is Nuclear Entanglement So Dangerous?” Carnegie Endowment for International Peace. Last modified January, 23, 2019. https://carnegieendowment.org/2019/01/23/why-is-nuclear-entanglement-so-dangerous-pub-78136.

Acton, James M., and Thomas C. Schelling. “Reclaiming Strategic Stability.” Edited by Elbridge A. Colby and Michael S. Gerson. STRATEGIC STABILITY: CONTENDING INTERPRETATIONS. Strategic Studies Institute, US Army War College, 2013. http://www.jstor.org/stable/resrep12086.7.

Airforce Technology, “Hypersonic Missile Integration with Aircraft,” August 14, 2023, https://www.airforce-technology.com/analyst-comment/hypersonic-missiles-aircraft-integration/.

“The Anti-Ballistic Missile (ABM) Treaty at a Glance.” Arms Control Association. Last updated December 2020, https://www.armscontrol.org/factsheets/abmtreaty

Bently, Ralph. *Strategy at Mach 5: Hypersonic Weapons in Chinese Military Strategy.* Air University. September 10, 2021. https://www.airuniversity.af.edu/Wild-Blue-Yonder/Article-Display/Article/2771133/strategy-at-mach-5-hypersonic-weapons-in-chinese-military-strategy/

Bhide, Jonah S. “Hypersonic Weapons: Strategic Drivers and Policy Proposals.” *Space & Defense* 12, no. 2 (Summer 2021): 75–94. https://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=a9h&AN=153089476&site=ehost-live&scope=site.

Bonsignore, Ezio. “Hypersonic Weapons: The Reasons Why.” Military Technology 45, no. 1 (January 2021): 32–34. https://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=a9h&AN=149206294&site=ehost-live&scope=site.

Brehm, Maya and Anna de Courcy Wheeler. *Hypersonic Weapons Discussion Paper for the Convention on Certain Conventional Weapons(CCW).* Article 36. Feb 2019. https://article36.org/wp-content/uploads/2020/12/hypersonic-weapons.pdf

“Broken Arrows: Nuclear Weapons Accidents.” Atomic Archive Accessed October 18, 2023. https://www.atomicarchive.com/almanac/broken-arrows/index.html

Bugos, Shannon and Kingston Reif. *Understanding Hypersonic Weapons: Managing the Allure and the Risks.* Arms Control Association. September 2021. https://safe.menlosecurity.com/doc/docview/viewer/docN6FCA22980417ae7ab14a2d486c14429c5ca0f91b561191f2517bb4779e66ed582c04a8bf7c71

Center for Arms Control and Nonproliferation. "Fact sheet: U.S. Ballistic Missile Defense." last modified June 12, 2023. https://armscontrolcenter.org/fact-sheet-u-s-ballistic-missile-defense/.

Chuter Andrew, "British Military scrambles to Speed up Work on Hypersonic Engines, Weapons", Defense News, Jul 18, 2019, https://www.defensenews.com/global/europe/2019/07/18/british-military-scrambles-to-speed-up-work-on-hypersonic-engines-weapons/.

Chyba, Christopher F. 2020. "New Technologies & Strategic Stability." *Daedalus* 149 no.2: 150–170. doi:10.1162/daed_a_01795

Cimbala Stephen J. and Adam Lowther, "Hypersonic Weapons and Nuclear Deterrence", *Comparative Strategy*, 41 no.3, (April 15, 2022): 282-295, DOI:10.1080/01495933.2022.2057736

Clark, Robert. "On Hypersonic Defence, the USA Has Shown That It Is the Ally That Matters". The Telegraph, 12 December 2023. https://www.telegraph.co.uk/news/2023/12/12/hypersonic-missiles-sm6-defence-interceptors-deploying/#:~:text=The%20SM%2D6%20Block%20IB,missile%20to%20reach%20hypersonic%20speeds.

Cohen, Rachel. 2019. "Hypersonic Weapons: Strategic Asset or Tactical Tool?" Air Force Magazine, May 7. http://www.airforcemag.com/Features/Pages/2019/May%202019/Hypersonic-Weapons-Strategic-Asset-or-Tactical-Tool.aspx

Cotterell, Arthur. "Chariot: The Astounding Rise and Fall of the World's First War Machine." Pimlico, London, 2004.

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

Davies, Andrew. "Coming Ready or Not: Hypersonic Weapons." Australian Strategic Policy Institute, 2021. http://www.jstor.org/stable/resrep31492.

Davis, Jacquelyn K. "Technology and Strategy: Lessons and Issues for the 1990s." The Annals of the American Academy of Political and Social Science 517 (1991): 203–16. http://www.jstor.org/stable/1047196.

Dean, Sidney E. "Conventional Prompt Strike: The US Navy's Hypersonic Weapons Programme." European Security and Defense. April 12, 2023. https://euro-sd.com/2023/04/articles/30723/conventional-prompt-strike-the-us-navys-hypersonic-weapons-programme/

Department of Defense. *National Defense Strategy of the United States of America, Including the 2022 Nuclear Posture Review and the 2022 Missile Defense Review*. Washington, DC: DOD, October 2022. https://apps.dtic.mil/sti/trecms/pdf/AD1183514.pdf

Department of Defense. *Quadrennial Defense Review Report*. Washington, DC: DOD, February 2010. https://dod.defense.gov/Portals/1/features/defenseReviews/QDR/QDR_as_of_29JAN10_1600.pdf

Deptula, David, and William Mahan. "VIEWPOINT: Collaboration Key to Developing Superiority in Hypersonics." National Defense 104, no. 788 (2019): 32–34. https://www.jstor.org/stable/27022646.

Ekmektsioglou, Eleni. *Hypersonic Weapons and Escalation Control in East Asia.* Strategic Studies Quarterly. Summer 2015. pp. 43-68. https://www.jstor.org/stable/26271074

Estes, Madison, Mary Boatright, Rick Cassleman, Sam Guthrie, Rafael Loss, Craig Neuman, Dev Patel, James H. V. To, and Kyle Yohoe. "New Futures for Nuclear Arms Control: Examining a Framework and Possibilities with Hypersonic Weapons." Edited by Simone Williams. *On the Horizon: A Collection of the Papers from the Next Generation*. Center for Strategic and International Studies (CSIS), 2020. http://www.jstor.org/stable/resrep24234.6.

Evans, Larry. "The Evolution of Firearms: A Historical Perspective," Accessed December 14, 2023, https://littlefeatherleather.com/The-Evolution-of-Firearms/

Feikert, Andrew. *"The U.S. Army's Long-Range Hypersonic Weapon (LRHW)."* Congressional Research Service. IF11991. Updated December 8, 2023. Available: https://crsreports.congress.gov/product/pdf/IF/IF11991

Frigoli, Matteo. *The Implications of the Advent of Hypersonic Weapon Systems for Strategic Stability.* Pugwash Conferences on Science and World Affairs. British Pugwash. December 2019.

Global Security.org. "CM-401, Anti-ship Ballistic Missile." Accessed March 8, 2024. https://www.globalsecurity.org/military/world/china/cm-401.htm.

Global Security.org. “DF-100 Long Sword-100 – Cruise Missile.” Accessed March 8, 2024. https://www.globalsecurity.org/wmd/world/china/df-100.htm

Gupta, Ritwik. *Orbital Hypersonic Delivery Systems Threaten Strategic Stability.* Bulletin of the Atomic Scientists. June 13, 2023. https://thebulletin.org/2023/06/orbital-hypersonic-delivery-systems-threaten-strategic-stability/

Heim, Jacob. *A Strategy-Driven Approach to the Research and Development of Hypersonic Missiles.* RAND, 2023. 1-20

Historical Office, Office of the Secretary of Defense “James, R. Schlesinger.” Accessed February 18, 2024, https://history.defense.gov/Multimedia/Biographies/Article-View/Article/571289/james-r-schlesinger/

Hruby, Jill. “HYPERSONIC DELIVERY SYSTEMS.” *RUSSIA’S NEW NUCLEAR WEAPON DELIVERY SYSTEMS: An Open-Source Technical Review*. Nuclear Threat Initiative, 2019. http://www.jstor.org/stable/resrep19984.8.

Jain, Smriti and Arunava Biswas. “BrahMos missile with higher range: This ‘killer’ India-Russia Project Will Scare Pakistan and China.” *Financial Express*, October 19, 2016. https://www.financialexpress.com/india-news/brahmos-missile-range-highlights-india-russia-modi-putin-mtcr-pakistan-china/424178/.

Khattak, Masood. “Indian Cold Start Doctrine: Capabilities and Limitations.” July 2010. Accessed October 14, 2023, DOI:10.13140/RG.2.2.29208.19203.

Kissinger, Henry. “Nuclear Weapons and Foreign Policy.” Harper and Brothers, New York, 1957

Klare, Michael T. “An ‘Arms Race in Speed’: Hypersonic Weapons and the Changing Calculus of Battle.” *Arms Control Today* 49, no. 5 (2019): 6–13. https://www.jstor.org/stable/26755134.

Koblentz, Gregory D. “Challenges to Strategic Stability.” Strategic Stability in the Second Nuclear Age. Council on Foreign Relations, 2014. http://www.jstor.org/stable/resrep21432.8.

Kroenig, Matthew. “Will Emerging Technology Cause Nuclear War?: Bringing Geopolitics Back In.” *Strategic Studies Quarterly* 15, no. 4 (2021): 59–73. https://www.jstor.org/stable/48638052.

Lee, Connie. “China, Russia Hypersonic Programs: Real Progress or Bluster?” *National Defense* 104, no. 788 (2019): 30–33. https://www.jstor.org/stable/27022645.

Lehman, Ronald F., and Thomas C. Schelling. “Future Technology and Strategic Stability.” In *Strategic Stability: Contending Interpretations,* edited by Elbridge A. Colby and Michael S.

Gerson., 147-200. Strategic Studies Institute: US Army War College, 2013. http://www.jstor.org/stable/resrep12086.8.

Lendon, Brad. “Russia Used an Advanced Hypersonic Missile for the First Time in Recent Strike, Ukraine Claims.” CNN. Last modified February 13. 2024. https://www.cnn.com/2024/02/13/europe/ukraine-russia-zircon-hypersonic-missile-intl-hnk-ml/index.html

Lendon, Brad and Yoonjung Seo. “North Korea Claims Another Successful Test of its Hypersonic Glide Missile Tech.” CNN. Last modified January, 15 2024. https://edition.cnn.com/2024/01/14/asia/north-korea-ballistic-missile-intl-hnk/index.html

Lowther, Adam and Curtis McGiffin. “America Needs a ‘Dead Hand.’” War on the Rocks. August 16, 2019. https://www.warontherocks.com/2019/08/amreica-needs-a-dead-hand/

Machi, Vivienne. “FUTURE WEAPONS: Rivals Push Pentagon to Boost Funding for Hypersonics Research.” *National Defense* 102, no. 764 (2017): 30–33. https://www.jstor.org/stable/27021835.

Magnuson, Stew. 2023. “Long-Range Fires: Japan Looks to Partner with U.S. on Railgun Project.” *National Defense* 107 no.834 (May 2023): 20–21. https://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=a9h&AN=163357754&site=ehost-live&scope=site.

Mattis, Jim. “Nuclear Posture Review,” 2018. https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF

Mattis, Jim. “Summary of the 2018 National Defense Strategy: Sharpening the American Military’s Competitive Edge,” 2018.

Maurer, John D. “The Future of Precision-Strike Warfare: Strategic Dynamics of Mature Military Revolutions.” Naval War College Review 76, no. 2 (2023): 13–38. https://www.jstor.org/stable/48735672.

Meilinger, Philip S. “Giulio Douhet and the Origins of Airpower Theory.” In *The Paths of Heaven: The Evolution Of Airpower Theory* edited by Philip S. Meilinger, 3 New Delhi, India: Lancer Publishers. 2002.

Missile Defense Project. "Avangard." Missile Threat, Center for Strategic and International Studies. January 3, 2019. last modified July 31, 2021. https://missilethreat.csis.org/missile/avangard/.

Missile Defense Project. "DF-17." Missile Threat, Center for Strategic and International Studies. February 19, 2020. last modified August 2, 2021. https://missilethreat.csis.org/missile/df-17/.

Missile Defense Project. "DF-21 (CSS-5)." Missile Threat, Center for Strategic and International Studies. April 13, 2016. last modified March 28, 2022. https://missilethreat.csis.org/missile/df-21/.

Missile Defense Project. "DF-26." Missile Threat, Center for Strategic and International Studies. January 8, 2018. last modified August 6, 2021. https://missilethreat.csis.org/missile/dong-feng-26-df-26/.

Missile Defense Project. "DF-31 (Dong Feng-31 / CSS-10)." Missile Threat, Center for Strategic and International Studies. August 12, 2016. last modified August 9, 2021. https://missilethreat.csis.org/missile/df-31/.

Missile Defense Project. "Kh-47M2 Kinzhal." Missile Threat, Center for Strategic and International Studies. March 27, 2018. last modified March 19, 2022. https://missilethreat.csis.org/missile/kinzhal/.

Olerich, Ivan. "Cool Your Jets: Some Perspective on the Hyping of Hypersonic Weapons. Bulletin of the Atomic Scientists. 2020 Vol. 76, No. 1, 37-45. DOI: 10.1080/00963402.2019.1701283

Pappalardo, David. 2022. "Hypersonics: Between Rhetoric and Reality." *Air & Space Operations Review 1*, no. 4 (Winter 2022): 78–88. https://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=a9h&AN=161130035&site=ehost-live&scope=site.

Payne, Keith B. "On Nuclear Deterrence and Assurance." *Strategic Studies Quarterly* 3, no. 1 (2009): 43–80. http://www.jstor.org/stable/26268917.

Powell, Wil, Jasmin Alsaied, Caitlyn Bess, Brandon Cortino, Daniel Gum, Annika Kastetter, Jaejoon Kim, et al. "The Hypersonic Weapon Threat: Resilient Deterrence despite Destabilizing Buzzwords." Edited by Reja Younis and Jessica Link. *On the Horizon: A Collection of Papers from the Next Generation*. Center for Strategic and International Studies (CSIS), (February 1, 2023): 136-145. http://www.jstor.org/stable/resrep47437.14.

Putin, Vladimir "Presidential Address to the Federal Assembly," Kremlin, March 1, 2018, http://en.kremlin.ru/events/president/news/56957.

Reny, Stephen. "Nuclear-Armed Hypersonic Weapons and Nuclear Deterrence." *Strategic Studies Quarterly* 14, no. 4 (2020): 47–73. https://www.jstor.org/stable/26956152.

Roland, Alex. “War and Technology.” Foreign Policy Institute. February 27, 2009. https://www.fpri.org/article/2009/02/war-and-technology/

Rossi, Melissa. *Will the Race to Develop Hypersonic Weapons Spark the Next Global Arms Race.* Yahoo News. July 2, 2022. https://news.yahoo.com/will-the-race-to-develop-hypersonic-weapons-spark-the-next-global-arms-race-110025468.html

Russell, Ruby, Alex Bednarek, Brian Benedicks, Alan Cummings, John Fernandez, B.M. Gautam, Matthew S. Golub, et al. “No First Nukes: Replacing the U.S. Nuclear First Strike Mission with Non-Nuclear Hypersonic Weapons.” Edited by Reja Younis. *On the Horizon: A Collection of Papers from the Next Generation*. Center for Strategic and International Studies (CSIS), 2021. http://www.jstor.org/stable/resrep29483.14.

Russian Federation. (2021) ‘Russian National Security Strategy, July 2021.’ https://paulofilho.net.br/wp-content/uploads/2021/10/National_Security_Strategy_of_the_Russia.pdf.

Satam, Parth. “Hypersonic Race Heats Up! France Becomes 2nd Western Country To Test Hypersonic Tech As US Struggles And Russia & China Lead.” *The EurAsian Times* June 30, 2023. https://www.eurasiantimes.com/hypersonic-race-heats-up-france-becomes-2nd-western-country/.

Sayler, Kyle M. “Hypersonic Weapons: Background and Issues for Congress”, *Congressional Research Service* R45811, (February, 13 2023): 1-36. https://sgp.fas.org/crs/weapons/R45811.pdf.

Scharre, Paul, and Ainikki Riikonen. “Introduction.” Defense Technology Strategy. New America, 2020. http://www.jstor.org/stable/resrep26976.3.

Schelling, Thomas C. “THE DIPLOMACY OF VIOLENCE.” *In Arms and Influence*, 1–34. Yale University Press, 1966. https://doi.org/10.2307/j.ctt5vm52s.4.

Sherman, Jason. “Navy Looking to Increase Range, Speed of SM-6 with Larger Rocket Motor.” Inside Defense, July 18, 2018. https://insidedefense.com/inside-pentagon/navy-looking-increase-range-speed-sm-6-larger-rocket-motor

Sugden, Bruce. *“Analyzing the Potential Disruptive Effects of Hypersonic Missiles on Strategy and Joint Warfighting”. Joint Forces Quarterly* 104, 1st quarter 2022, 6-21. https://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-104/jfq-104_6-21_Sugden.pdf?ver=i6Gkwx5d8F6Rc2PjVwcQ1Q%3d%3d

Sultan, Adil and Itfa Khursheed. "Hypersonic Weapons in South Asia: Implications for Strategic Stability". *IPRI Journal,* 21 no.1, (June 30, 2021): 1-21. https://journal.ipripak.org/wp-content/uploads/2021/07/Article-3-IPRI-Journal-XXI-1.pdf

Terry, Nathan B., and Paige Price Cone. "Hypersonic Technology: An Evolution in Nuclear Weapons?" *Strategic Studies Quarterly* 14, no. 2 (2020): 74–99. https://www.jstor.org/stable/26915278.

Ukrinform, "3M22 Zircon: What is Known About Missile that Russia Could Have Launched at Kyyiv," February 12, 2024, https://www.ukrinform.net/rubric-ato/3826177-3m22-zircon-what-is-known-about-missile-that-russia-could-have-launched-at-kyiv.html

Watts, John T., Christian Trotti, and Mark J. Massa. "HYPERSONIC WEAPON-DEFENSE SYSTEMS." *PRIMER ON Hypersonic Weapons in the Indo-Pacific Region*. *Atlantic Council*, (2020): 10-11. http://www.jstor.org/stable/resrep26035.7.

Watts, John T., Christian Trotti, and Mark J. Massa. "PULSE CHECK: TRACKING HYPERSONIC WEAPON DEVELOPMENT OF THE INDO-PACIFIC POWERS." *PRIMER ON Hypersonic Weapons in the Indo-Pacific Region*. *Atlantic Council*, (2020): 11-22. http://www.jstor.org/stable/resrep26035.8.

Wiener, Rachel, Christopher M. Conant, Jared Dunnmon, Dean Ensley, Ashley E. Green, Rebecca Friedman Lissner, Harrison Menke, et al. "The Impact of Hypersonic Glide, Boost-Glide, and Air-Breathing Technologies on Nuclear Deterrence." Edited by Mark Cancian. Project on Nuclear Issues: A Collection of Papers from the 2016 Nuclear Scholars Initiative and PONI Conference Series. Center for Strategic and International Studies (CSIS), 2017. http://www.jstor.org/stable/resrep23162.14.

Wilkening, Dean. 2019. "Hypersonic Weapons and Strategic Stability." *Survival* 61, no.5 (2019): 129–148. doi:10.1080/00396338.2019.1662125.

Williams, Heather (2019) Asymmetric arms control and strategic stability: Scenarios for limiting hypersonic glide vehicles, Journal of Strategic Studies, 42:6, 789-813, DOI:10.1080/01402390.2019.1627521

Wortzel, Larry M. *Hypersonic Weapons Development in China, Russia and the United States – Implications for American Security Policy.* Land Warfare Paper 143, Association of the United States Army. March 2022. https://www.ausa.org/publications/hypersonic-weapons-development-china-russia-and-united-states-implications-american

Yohoe, Kyle, Mary Boatright, Rick Cassleman, Madison Estes, Sam Guthrie, Rafael Loss, Craig Neuman, Dev Patel, and James H. V. To. "An Offensive Leap: An Analogy of Hypersonic Weapons to Early ICBMs." Edited by Simone Williams. *On the Horizon: A Collection of the Papers from the Next Generation*. Center for Strategic and International Studies (CSIS), 2020. http://www.jstor.org/stable/resrep24234.12.

Zhao, Tong. "Going Too Fast: Time to Ban Hypersonic Missile Tests?" *Bulletin of the Atomic Scientists* 71, no. 5 (September 2015): 5–8. doi:10.1177/0096340215599774.