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PRIMER ON

Hypersonic Weapons in the Indo-Pacific Region

John T. Watts · Christian Trotti · Mark J. Massa

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Cover image: In this US Department of Defense (DOD) design, the Defense Advanced Research Products Agency's (DARPA's) Falcon Hypersonic Test Vehicle emerges from its rocket nose cone and prepares to re-enter the Earth's atmosphere. *Source: DOD illustration https://www.defense.gov/Explore/News/Article/Article/1934290/hypersonics-remain-top-priority-for-dod/#pop3612183*

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Executive Summary

While the ability of vehicles to travel at hypersonic speeds—between Mach 5 and Mach 25—has been possible for more than half a century, the capability for reliable, sustained hypersonic flight has only recently neared maturation. Motivated by the return of great-power competition and the potential asymmetric advantages provided by weapons travelling at such speeds, three nations—the United States, China, and Russia—are now at the forefront of developing operational hypersonic weapons. Meanwhile, several other Indo-Pacific states are seeking to develop such capabilities in the intermediate future.

This increased attention has been accompanied by ongoing debate about the strategic and military significance of hypersonic weapons. In short, will they fundamentally change the balance of power, or will they provide more of an evolved capability? The answer is still unclear, in part because their ultimate capability will be unknown until the technologies reach full maturity, but also because it is not yet apparent how nations will employ them in the future or what norms may be developed to constrain their employment.

Amidst such ambiguities, debates about new military technologies are valuable in preparing for alternative futures. Yet, such debates are too often defined by technological opportunities and limitations. In reality, it is impossible to divorce these systems from the broader contexts in which they will operate, as the technologies themselves are only part of the equation. Indeed, a variety of weapons systems can broadly be characterized as "hypersonic weapons," each with specific characteristics, tradeoffs, and potential applications. When confronted by such choices, there is no single path forward; policymakers and military planners should instead consider how the capability at hand can maximize leverage and solve dilemmas within their unique strategic environments. This explains why the technological opportunities and constraints inherent in hypersonic weapons have not uniformly affected US, Chinese, and Russian development programs; rather, their respective military strategies have played an important role in shaping early and evolving perceptions. Thus, analysts and policymakers cannot begin to understand and chart the implications of these weapons, as well as future escalation and conflict pathways, without properly situating them within the underlying geostrategic and regional contexts in which the major players operate.

Therefore, this primer seeks to marry technological characteristics, geostrategic and military imperatives, and regional dynamics in order to provide a basis for further analysis about hypersonic development and application trajectories in the Indo-Pacific. This particular region was chosen because it is a common geographic locus of all three leading nations, as well as a majority of near-capable follower nations, while also containing several potential flashpoints that could trigger a high-end conventional military confrontation. Accordingly, it is the most likely region in which states may witness the deployment and use of hypersonic weapons in the near term, which may radically redefine regional defense dynamics. Despite these risks, many regional actors do not appear to have robust plans for responding to or defending against these systems, as they may be constrained by a lack of understanding about how regional dynamics may be altered. Thus, the intent of this primer is to lay out the contours of the debate from a policymaker's perspective by articulating the key issues in a straightforward way, in order to further the discussion about the ways in which hypersonic weapons may change the balance of power in the Indo-Pacific. To do this, it will cover several key facets of the current debate.

First, the primer outlines the technological characteristics and applications of hypersonic vehicles. While hypersonic travel has been a scientific reality since space reentry vehicles in the 1960s, current hypersonic weapons are different because they are designed to fly at hypersonic speeds for sustained periods and are potentially maneuverable throughout their flight. There are currently three main forms of hypersonic weapons: "boost-glide," "airbreathing," and "gun-launched." The potential applications for each of these weapons vary based on their characteristics. A hypersonic glide vehicle would need to be launched like other rocket systems, such as intercontinental ballistic missiles (ICBMs). They can travel at the upper limits of the accepted hypersonic speed range and are well suited to long-range employment. An airbreathing hypersonic missile, on the other hand, would likely be carried by an aircraft and employed in a similar manner as a conventional cruise missile, with slower speeds and shorter range than a boost-glide system, but with greater tactical flexibility. Gun-launched hypersonic projectiles would be launched by, and employed as, enhanced versions of naval guns or artillery pieces with speeds at the low end of the spectrum and shorter comparative ranges.

Second, the primer reviews the current debate over the ultimate military relevance of hypersonic weapons, using potential escalation pathways in the Indo-Pacific as examples. Those who proclaim the significance of this emerging capability argue that the compression of decision-making processes created by the limited time between launch and strike of the target ("flash to bang"), combined with its survivability against modern and near-term air-defense systems, makes this weapon a "game changer." Indeed, it presents difficult tactical, operational, and strategic dilemmas to a targeted force, which must balance among unfavorable alternatives such as dispersion, hardening, and the reconsideration of forward deployments. Moreover, even if they are never used, hypersonic weapons compound the existing ambiguity inherent in current deterrence calculations, presenting a threat of surprise that may incentivize rapid escalation, preemptive action, and strategic miscalculation. Their greatest impact likely would be as delivery mechanisms for conventional, rather than nuclear, warheads, which could paradoxically increase the likelihood of their use and, therefore, of escalated conflict.

On the other hand, those who doubt the military relevance of these systems argue that they are more of an evolutionary, rather than a revolutionary, capability in that they merely produce the same military effects achieved by existing capabilities. For example, cruise missiles are already maneuverable, and ICBMs already travel at speeds that even the most advanced militaries struggle to counter. Does the fact that hypersonic weapons combine the maneuverability of cruise missiles and the speed of ICBMs make them a qualitatively new capability? And, what greater threat do they pose if potentially targeted nations are already vulnerable?

Third, the primer conducts a "pulse check," or quick summary, of the current status of hypersonic-weapons development and strategic planning among the three great powers, as well as the United States' allies and partners in the Indo-Pacific region. Informed by their respective security environments, the United States, China, and Russia have all tailored their hypersonic-weapons programs to achieve different strategic objectives. The United States, for example, seeks to integrate these systems into its conventional prompt global strike (CPGS) capability, in part to offset revisionist threats against, and even supplement, its forward-deployed deterrent forces. This approach requires a high degree of accuracy and reliability, as well as a wide variety of delivery mechanisms across warfighting domains, which has shaped progress toward a more diversified hypersonic weapons portfolio. Russia and China, on the other hand, view hypersonic weapons as an increased strategic deterrent, both in enhancing their nuclear second-strike capability and as a supplement to their anti-access/area denial (A2/AD) posture. Accordingly, these strategic motivations are manifest in the respective development programs of these three countries.

Beyond these leading nations, priorities and perceptions in the Indo-Pacific are mixed. Australia, India, and Japan have various foundations for offensive and defensive hypersonic capabilities, as well as nascent planning for developing and deploying those capabilities (likely in the 2025–2035 timeframe). Even so, the time lag to employment may constitute a window of vulnerability that great-power adversaries could exploit in order to achieve regional security goals under an umbrella of hypersonic strike. Other advanced militaries in the region—the most prominent of which are Singapore, South Korea, and Taiwan—appear to have little publicly released information on addressing the hypersonic threat or developing their own capabilities.

Fourth, and finally, the primer reflects on security implications for the Indo-Pacific. One major consequence would likely be increased freedom of maneuver for China and Russia in the region. By using hypersonic weapons to increase the risks of conventional conflict for the United States and its allies, thereby keeping the threshold for war high, Chinese and Russian policymakers create greater space for their "gray zone," hybrid, and irregular activities. Therefore, hypersonic weapons can affect multiple tiers of the escalation ladder. Additionally, all nations within adversarial hypersonic-strike ranges must accept the threat of a near-instantaneous strike with little to no warning if they attempt to confront or resist Chinese or Russian aggression. This will remain a reality until the United States and/or regional nations can develop sufficient counterbalancing capabilities, including in suborbital detection and tracking, interdiction, and counterstrike. Some nations have already begun to address this shift in the balance of power, but more time is needed.

Regardless of the ultimate threat posed by hypersonic-strike systems, they will prove to be a potent military capability. This is due not only to their speed, which at the very least compresses response times within the region to a point that will make interdiction with current systems extremely difficult, but also to their maneuverability and unconventional flight paths, which make them nearly impossible to track with existing surveillance systems. Thus, they have the potential to impose profound changes on the military and political calculus of both the great and regional powers in the Indo-Pacific. Indeed, there will be numerous potentially significant second- and third-order implications of this change in the balance of power, including in ways that may not be obviously connected or overtly risky. Due to the great powers' lead in deploying these capabilities, regional nations should prioritize development of an effective defense against them, especially one that is both collective and coordinated.

Primer on Hypersonic Weapons in the Indo-Pacific Region

INTRODUCTION

The term "hypersonic" has become increasingly ubiquitous in defense and military discourse over the last few years. Even though research into this technology dates back more than seventy-five years, and operational prototypes have been demonstrated for more than fifty years, this technology has only recently begun to reach operational capability.

This maturation has been driven, in part, by both the rise of Russia and China as regional powers and their increased investments in technologies that may provide disruptive or asymmetric advantages over the United States, thereby challenging US military overmatch. All three nations are now racing to operationalize this capability in order to meet their national objectives—though in very different ways and for different purposes.

This paper will summarize what is meant by "hypersonic weapons"—as the term is broad and covers a range of weapon systems—as well as their likely military relevance in the future and the main arguments about their ultimate effect. It will then give an overview of how the leading developers of these capabilities—the United States, Russia, and China—view the capabilities, how they see them fitting into their respective national strategies, and what progress they have made in developing the capability.

The Indo-Pacific is arguably the most likely theater to be impacted by hypersonic weapons, as all three leading developers of this capability, and many of the nations involved at a lower tier of development, are located across the broader region. It also contains several potential flashpoints that could trigger a high-end conventional military confrontation. Moreover, hypersonic weapons have the potential to radically reshape regional defense dynamics—regardless of whether they are ever employed—so this primer will seek to contextualize the broader risks and implications of hypersonic weapons for regional nations. It will also examine how the most advanced and capable US military allies and partners in the Indo-Pacific view hypersonic weapons, and how they are preparing for the emergence of this capability.

A boost-glide hypersonic weapon relies on a rocket to launch it into a low-Earth orbit, where the hypersonic projectile then detaches and glides on top of the atmosphere to its target. This design of the Air-Launched Rapid Response Weapon (ARRW) shows the rocket and projectile in low-Earth orbit prior to detachment. *Source: Lockheed Martin Corporation*

Airbreathing hypersonic missiles would likely be carried by aircraft and employed like conventional cruise missiles. In this design, the US Air Force's experimental X-51 Waverider, shown here under the wing of a B-52 Stratofortress, is set to demonstrate hypersonic flight. Powered by a Pratt & Whitney Rocketdyne SJY61 scramjet engine, it is designed to ride on its own shockwave and accelerate to about Mach 6. *Source: US Air Force graphic https://www.af.mil/News/Photos/igphoto/2000360694/*

The full extent of the security implications of this technology are not yet clear. What is clear, however, is that its unique characteristics mean that regional cooperation and understanding are more vital than ever if regional security and strategic stability are to be maintained.

BACKGROUND

Hypersonic vehicles are those that travel above Mach 5 (i.e., five times the speed of sound)—approximately 3,400 miles per hour (mph) or 1–5 miles per second. The category of "hypersonic" is also usually bounded at the high end at Mach 25—approximately 17,500 mph. This definition covers a broad range of speeds, which have very different physical characteristics and implications.

Research into hypersonic travel dates to the early 1930s and led to many of the rocket breakthroughs achieved by Germany in World War II.[1] After 1945, ongoing interest in ICBMs and space travel advanced the technologies that would eventually enable hypersonic vehicles. Indeed, any object reentering the Earth's atmosphere typically travels at speeds near 17,500 mph, or Mach 25, so human travel at hypersonic speed has been a reality since the 1960s—albeit only for short, unsustained bursts.[2]

Hypersonic weapons are different in nature from space reentry vehicles, predominantly because the former are designed to fly at hypersonic speeds for sustained periods and are potentially maneuverable throughout their flight. There are currently three main forms of hypersonic weapons: "boost-glide," "airbreathing," and "gun-launched." Each has a different form factor, characteristics, and potential military application.

Akin to the reentry of a space rocket, a "boost-glide" hypersonic weapon relies on a rocket to launch into a low-Earth

1 Travis Hallen and Michael Spencer, "Hypersonic Air Power," Air Power Development Centre, Royal Australian Air Force, April 20, 2017 *http://airpower.airforce.gov.au/APDC/media/PDF-Files/BPAF%20Series/BPAF01-Hypersonic-Air-Power.pdf*

2 Tom Benson, "Speed Regimes: Hypersonic Re-Entry," Glenn Research Center, US National Aeronautics and Space Administration, last updated June 12, 2014, *https://www.grc.nasa.gov/WWW/BGH/hihyper.html*

While often discussed separately from boost-glide and airbreathing hypersonic weapons, railgun weapon systems can achieve hypersonic speeds and may be valuable in supporting air and missile defense in the future. *Source: General Atomics Electromagnetic Systems https://www.ga.com/railgun-weapon-systems*

orbit, where it detaches and "glides" on top of the atmosphere—unpowered—to its target.[3] This approach has several advantages, including that its rocket propulsion is relatively simple and can generate propulsion even in low-oxygen atmospheric conditions. This model also tends to have greater range and speed, as it can operate outside the Earth's atmosphere, where air density and temperature are lower, thereby reducing aerodynamic drag and thermal effects on the vehicle, while allowing for a simpler and lighter design.

Hypersonic "airbreathing" weapons use supersonic combustion ramjet ("scramjet") engines that combust fuel within a stream of supersonic air passing through the vehicles. In these engines, the speed of airflow naturally compresses the air for combustion. Therefore, the engines do not need the motorized fan blades that traditional jet engines use for pre-combustion compression. In many ways, this makes the entire system simpler and more reliable.[4] However, it also means they cannot work below Mach 5 and so need some form of accelerator such as an initial rocket or—more likely for weapons—a launch vehicle that can release it at the edge of hypersonic travel. While "airbreathing" hypersonic vehicles will theoretically be able to reach speeds of Mach 15, to date they have only achieved test speeds of Mach 9.6. Their advantage over rocket propulsion is a greater thrust efficiency and lighter weight when operating within the Earth's atmosphere.

A third method for a weapon achieving hypersonic speeds is through gun-launched systems. These weapons are nearing operational capability, but are usually discussed separately from the other two weapon types, as they resemble enhanced artillery (with shorter ranges and speeds at the lower end of the "hypersonic" designation) rather than missile systems.[5] "Railgun" launchers, for example, use an electromagnetic pulse to propel projectiles up a launching rail. The technical

3 In military application, this is usually an intercontinental ballistic missile (ICBM) or a sea-launched ballistic missile (SLBM), which all "great powers" have already developed and deployed.

4 *Bob* Allen, "How Scramjets Work," Langley Research Center, National Aeronautics and Space Administration, last updated April 22, 2008, *https://www.nasa.gov/centers/langley/news/factsheets/X43A_2006_5.html*

5 Euan McKirdy, "China Closer to Equipping Warships with Electromagnetic Railguns, State Media Reports," CNN, January 4, 2019, *https://www.cnn.com/2019/01/04/asia/china-pla-navy-railgun-intl/index.html*

Hypersonic Missile Employment Options

Application	Propulsion/ Type	Approximate Range	Projected speed (approx.)	Launch mode
Non-nuclear ICBM / Conventional Prompt Global Strike (CPGS)	Boost-glide	3,400+ miles	Up to Mach 20	Submarine, ship, land
Surface-to-surface ballistic missiles	Boost-glide	1,500+ miles	Up to Mach 20	Submarine, ship, land
Strike missile (e.g., anti-ship)	Scramjet, Boost-glide	250 miles 1,500+ miles	Mach 8 Mach 20	Submarine, ship, air
Interceptor missiles	Scramjet	250 miles	Mach 5-7	Air
Enhanced naval guns and artillery	Gun-launched (rail and powder)	100 miles	Mach 6-8	Ship, land
Piloted (ISR, air mobility)	Manned aircraft	Up to 10,000 miles	Mach 5	Self-propelled

Source: Author developed

challenges for their design relate more to the vast amounts of electricity needed to launch them than the aerodynamic characteristics of flight or design compromises required for sustained travel. Another gun-launched method is "hypervelocity projectiles" (HVP). These are artillery rounds designed to fire from existing standard powder guns (such as a MK-45 5-inch deck gun or ground-based 155-milimeter (mm) howitzer artillery), but can reach hypersonic speeds of around 5,600 mph.[6] These weapons are unlikely to significantly alter existing concepts of operation or threat assessments, but they may be highly valuable defensive tools for countering other strike weapons (potentially including hypersonic ones), and are cheaper and more tactically flexible than other missile-defense systems.

The potential applications for each of these weapons vary based on their characteristics. A hypersonic glide vehicle would need to be launched in the same ways as other rocket-launch systems such as ICBMs. These vehicles can travel at the upper limits of the hypersonic speed range and are well suited to long-range employment. An airbreathing hypersonic missile, on the other hand, would likely be carried by an aircraft and employed in a similar manner as a conventional cruise missile. Airbreathing hypersonic weapon speeds currently lie around the middle of the hypersonic spectrum and have intermediate range but greater tactical flexibility. Finally, gun-launched hypersonic projectiles would be launched by, and employed as, enhanced versions of naval guns or artillery pieces with speeds at the low end of the spectrum and shorter comparative ranges—just beyond current employment ranges.

There are several ways in which hypersonic missiles could be employed, as shown in the table above.

The speed of the weapons creates several advantages. It shortens the response time available to the targeted adversary, increasing the likelihood of success while reducing adversaries' opportunities to respond. This speed also increases the chances of a successful strike due to the difficulty of intercepting an object travelling at that speed. This capability is further complemented by the maneuverability of glide and airbreathing missiles, which makes them extremely difficult to intercept or defend against utilizing current or near-term defensive systems. Lastly, the kinetic energy contained within the weapon imbues it with a destructive quality apart from any warhead or explosive weapon with which it is armed—in many non-nuclear cases, this would produce sufficient energy to potentially destroy a target without the need for an explosive warhead.

Technical Feasibility

Unsurprisingly, there are significant scientific and engineering challenges to making hypersonic flight possible. Moreover, each challenge creates implications and tradeoffs for the design and application of the weapon;

6 Sam LaGrone, "Navy Quietly Fires 20 Hyper Velocity Projectiles Through Destroyer's Deckgun," *USNI News*, January 8, 2019, *https://news.usni.org/2019/01/08/navy-quietly-fires-20-hyper-velocity-projectiles-destroyers-deckgun*

therefore, it is important to understand the *how* and *why* of some of the key considerations in order to appreciate their potential military application and limitations. The likely threat, and potential responses to it, will be dramatically affected by the type of weapon and its inherent design characteristics. Each needs to be considered on its own merits.

At different speeds, the gas molecules in the air react differently to an object moving through it. The ratio of the speed of the object relative to the speed of sound is the measurement used to understand these different reactions, and is referred to as the Mach speed. This provides a constant baseline relative to the speed of sound at sea level, though it should be noted that the actual speed of sound in a gas is also affected by temperature and density, and therefore also varies at different atmospheric levels—or elevation—as the air is cooler at increased altitudes. Gas dynamics are extremely important in understanding hypersonic flights.[7] At higher speeds, around Mach 10, gas particles begin to dissociate as chemical bonds are broken. As an object reaches Mach 25 (around 17,000 mph) the temperature of the flow of air becomes so great that the particles ionize and create an electrically charged plasma around the object, which can affect communications.[8]

As a result, the advancement of material sciences is a key element in the development of effective hypersonic weapons. Expensive alloys such as nickel and titanium, as well as heat-resistant ceramics, are necessary to resist the extreme temperatures. Even with the use of advanced insulation, at high temperatures the strength and stiffness of structural elements of the vehicle can be compromised. There are various approaches to managing the challenges of extreme heat. But, all these mitigation strategies have tradeoffs—such as increased weight—that must be balanced with the rest of the design. In the case of hypersonic weapons, techniques such as ablative coatings—which are designed to burn off during flight to dissipate heat—are possible due to their single-use nature.

The plasma sheath that forms at the upper spectrum of hypersonic speeds (around Mach 25) also disrupts electromagnetic signals, making it difficult to communicate with the hypersonic vehicle while in flight. This impacts the ability of the vehicle or weapon to navigate, and for mission control to redirect it above Mach 10—though that will likely only apply to a small subset of systems (mostly boost-glide systems used in a ballistic-missile application) and at particular stages, such as reentry. As a result, however, hypersonic weapons may need the ability to slow to supersonic or subsonic speeds during terminal stages of flight in order to confirm and update targeting and navigational orientation. This could have implications for the destructive effect of the weapon (as it would reduce kinetic energy) and potential interdiction by close-in defense systems (which would nonetheless be extremely challenging).[9]

MILITARY SIGNIFICANCE

There is currently a heated debate about the ultimate impact of hypersonic weapons. Those who proclaim these weapons' significance argue that the compression of decision-making processes created by the limited time between launch and strike of the target, combined with their survivability against modern and near-term air-defense systems, makes these weapons a "game changer." Others argue that they merely achieve the same military effect that existing capabilities do, but in an enhanced manner: cruise missiles are already maneuverable, for instance, and ICBMs already travel at speeds that even the most advanced militaries can barely counter (and are actually travelling faster than hypersonic glide vehicles (HGVs) during the terminal phase).

The difference with hypersonic weapons—at least those most often discussed—is that cruise missiles lack speed and most ballistic missiles cannot maneuver (a handful of maneuverable reentry vehicles are the exception). Hypersonic weapons can do both. Is that sufficient to consider them a qualitatively new capability? Currently, only a few weapons systems are operational, and, ultimately, the answer is hypothetical until the systems have matured and nations begin responding to them in real time. Nonetheless, it is worth considering the different sides of the argument in order to prepare for any eventuality.

Argument: They change the balance of power

The key advantage of hypersonic weapons—and the primary argument for their disruptive capability—is that their speed is, in and of itself, a qualitative game changer. That is, the speed of the weapons means that many existing radars will be unable to track them, thereby undermining key components of a layered air-defense system (in reality, their unusual trajectory is as significant a factor in this challenge). The survivability of the SR-71 Blackbird reconnaissance plane—which flew only at the supersonic speed of Mach 3—is used as evidence of this argument. It is argued that

7 Hallen and Spencer, "Hypersonic Air Power."

8 Benson, "Speed Regimes: Hypersonic Re-Entry."

9 Hallen and Spencer, "Hypersonic Air Power."

Hypothetical Escalation Pathway #1

Consider, for instance, an escalating conflict between North and South Korea, in which China decides to intervene on North Korea's behalf. China decides to preempt further escalation and strike at key South Korean military installations. Without warning, it fires several hypersonic missiles from within Chinese territory. Even with Terminal High-Altitude Area Defense (THAAD), US and South Korean forces would have perhaps five minutes to detect a launch, determine its point of departure, recognize the geopolitical implications of the escalation, discriminate and track the missiles, prepare defense systems for launch, and then successfully interdict them. Such a sudden shift would be shocking at any time, but to recognize it for what it is (i.e., not dismissing it as a test, demonstration, or false reading) and activate defensive measures within the time it takes to make a cup of coffee would be nearly impossible. US forces, as well as the forces of US allies and partners, will be particularly vulnerable. Hypersonic weapons may embody the ideal tool for China to achieve revisionist *fait accompli* attacks.

the difficulty in detection, combined with the severely compressed time available for response, means that even if the sensors can effectively track the weapons, the short time—in some cases, minutes—to detect the launch, discriminate the target, and prepare and fire a countermeasure could overwhelm command-and-control systems. **Hypothetical Escalation Pathway #1** demonstrates how the speed of hypersonic weapons alone could threaten US and allied defenses in the Indo-Pacific.

This ability also effectively forces a "reconsideration of traditional second-strike calculations, as [hypersonic weapons] have the potential to decapitate a nation's leadership before it has the opportunity to launch a counterattack."10 Moreover, the compressed response time, combined with the long-range reach, means that a targeted force must tactically adjust to the increased threat through dispersion, which would then increase its vulnerability to swarmed mass assault, or alternatively increase the hardening of capabilities, which would limit speed and maneuverability. This may also compel reconsideration of the forward-deployed basing of key capabilities, either moving them farther away, thereby reducing their response time and risking early telegraphing of military actions to an adversary, or operating under unacceptable levels of risk. In this way, even a tactical hypersonic-strike capability could have a strategic effect, as it may force the United States and its allies to rethink how and where they posture their forces—potentially leaving regional partners more vulnerable to surprise attack. The regional implications of this threat for US and allied force posture in the Indo-Pacific are evident in **Hypothetical Escalation Pathway #2.**

While the speed of hypersonic weapons is the most prominent advantage, the ability to maneuver in flight should

Hypothetical Escalation Pathway #2

Consider a potential scenario that could occur across Asia wherein the threat of hypersonic strike by either China or Russia puts US bases in South Korea, Japan, Philippines, and elsewhere under direct threat and reduces the presence of US aircraft carriers and/or other strategic assets. Not only would it significantly reduce the deterrent value of US forces in those locations but also reduce the speed with which they could respond to any surprise military aggression. The extended distances could also significantly complicate logistics and operational support, limiting planning options and some operational missions (such as long-range air strike or air interdiction).

This could result, for instance, in an attempted seizure by China of the Senkaku Islands or Russia of the Kuril Islands. While Japan's own self-defense force is capable enough to repel such an attempt on its own, a precursor strike on key Japanese facilities and capabilities combined with reduced US presence may create a window of opportunity for the aggressor.

Moreover, would the reduced or distanced US presence change China's political and operational calculations about more forcefully seizing the Spratly Islands? How would any of the claimants respond? What would Indonesia do if China did the same to the Natuna Islands? Would a reduced US presence in the region shift the political appetite and change the strategic options for regional nations such that they would need to become more accepting of Chinese expansionist actions in order to reduce the risk of a confrontation?

In these scenarios, hypersonic weapons may not even be used—but their presence may shift US force posture to a degree that they created increased risk of aggression and coercion.

10 Richard H. Speier, "Hypersonic Missiles: A New Proliferation Challenge," RAND, May 29, 2019, *https://www.rand.org/blog/2018/03/hypersonic-missiles-a-new-proliferation-challenge.html*

not be underestimated. The maneuverability of the weapon can also exponentially reduce the time in which a targeted nation has to respond. That is because the ultimate target may not be apparent at launch. ICBMs follow a predictable trajectory, so a target can be discerned after a launch is detected. Since the hypersonic missile may change its flight path midflight, it can therefore redirect toward a different target at virtually any time. In a crowded region, such as Southeast Asia, this means a launch could ultimately impact any nation, as demonstrated in **Hypersonic Escalation Pathway #3**. This creates a new dynamic as any bilateral confrontation could instantly expand and escalate during the first strike. Therefore, nations must consider counter-hypersonic defenses as a regional imperative, while coordinating defensive measures with neighboring nations.

Interestingly, conventional applications of hypersonic weapons may be the most impactful. Although Russia has mostly focused on developing hypersonic weapons as a new form of delivery for a nuclear payload, some analysts argue that a non-nuclear hypersonic-strike capability may create greater risk.[11] Risk is ultimately a product of likelihood and consequence; the consequence of a non-nuclear strike may be lower than that of a nuclear strike, but if the likelihood of the former is sufficiently increased, then the overall risk would increase as well.

Indeed, conventionally armed hypersonic weapons are more likely to be employed and would therefore bear more significant implications for deterrence. Since both China and Russia already have a second-strike nuclear capability vis-à-vis the West (in that Western nations cannot deny or preempt a Chinese or Russian nuclear strike), a nuclear-armed hypersonic-weapon system is merely an extension of the status quo (aside from reducing in-theater response times) and does not appear to contribute much strategic value. Moreover, due to the deterrent effect of mutually assured destruction (MAD) and the massive military, political, and economic consequences involved, nations would hesitate to employ nuclear weapons at all, except under the most extreme circumstances. In several key cases, this is already enshrined in a “No First Use” policy or a pledge to only use them defensively. Therefore, changing the balance of power at lower tiers of the escalation ladder, without resorting to high-end conventional or nuclear war, would require a significant non-nuclear strike capability. This may be the greatest added value of hypersonic weapons. The speed and maneuverability of hypersonic weapons may increase the Chinese and Russian ability to strike in non-nuclear form, wherein the escalation and consequences would be comparatively lower, thereby changing their political calculations and increasing the likelihood that countries would employ that capability. This could shape the outset or early stages of great-power conflict.

Even without an increased employment or use of the system, hypersonic weapons compound the existing ambiguity inherent in current deterrence calculations. Since their inherent advantage of surprise at the outset of a conflict incentivizes rapid escalation, they increase the risks of strategic miscalculation and preemptive action, thereby affecting strategic stability and decision-making during peacetime and crises.[12]

Tactically, the maneuverability of these weapons can dramatically change defensive postures. Presently, defensive systems can be postured toward the likely direction of attack because, in most cases, current systems have demanding requirements that determine the location from which they can be launched (submarine-launched weapons are the most prominent exception to this, which is a major contributor to their strategic value). Some experts believe existing defensive systems, such as Terminal High-Altitude Area Defense (THAAD), can be adapted to effectively and reliably negate

Hypothetical Escalation Pathway #3

Consider, for instance, a less probable but still plausible contingency in which fisheries and sovereign tensions escalate in the North Natuna Sea between China and Indonesia. China launches a hypersonic missile to strike against an oil refinery in Indonesia—for instance, PT Pertamina’s facility in Dumai on the Island of Sumatra—in an attempt to damage its economy and threaten the Malacca Strait. Indonesia, expecting a military strike, is on high alert.

Other regional countries, not being a party to the dispute, may be on alert, but do not expect an imminent attack. As China launches its strike, the Association of Southeast Asian Nations (ASEAN) announces solidarity with Indonesia and denounces China’s aggression. During the terminal phase—less than a minute from impact—the trajectory of the HGV could be changed to target any regional nation, putting at risk Malaysia, Singapore, or Brunei—without giving the targeted nation any indication that a strike was imminent until the moment of impact.

11 James M. Acton, “Hypersonic Weapons Explainer,” Carnegie Endowment for International Peace, April 2, 2018, *https://carnegieendowment.org/2018/04/02/hypersonic-weapons-explainer-pub-75957.*

12 Douglas Barrie, “Unstable at Speed: Hypersonics and Arms Control,” International Institute for Strategic Studies, October 18, 2019, *https://www.iiss.org/blogs/military-balance/2019/10/hypersonics-arms-control.*

The Defense Advanced Research Projects Agency's (DARPA's) Glide Breaker program began in 2018 to develop and demonstrate technologies to enable defense against hypersonic systems. *Source: DARPA graphic https://www.darpa.mil/program/glide-breaker*

a hypersonic strike. But, even if they are, they would need to be postured for a 360-degree defense, as the strike weapon could maneuver in flight, thereby increasing the number of possible attack vectors. This creates a significantly increased burden on defensive coverage.

Counterargument: They will provide an evolved capability, but are not a game changer

One of the key arguments made by skeptics of hypersonic systems is that air-defense systems already struggle to defeat existing missile systems, and the added invulnerability of hypersonic weapons is therefore redundant. Moreover, the political response to a missile strike—regardless of whether it is hypersonic or an existing ICBM—will be the same. That is, it will be viewed as an act of conventional war and responded to as such. Therefore, the argument is that existing frameworks for ICBMs and missile nonproliferation are sufficient and appropriate for addressing the threat of hypersonic weapons. Moreover, for countries that already lack ballistic-missile capabilities, hypersonic weapons represent only a small increase in risk, as they lack an existing deterrent and are unlikely to have conventional missile-defense systems.

The technical challenges are also often cited as a reason to be skeptical. For instance, while the ability to maneuver midflight theoretically creates a disruptive capability, it also poses additional technical challenges, such as increased heat from increased atmospheric friction, as well as the communications challenges discussed above. While Russia and China claim to have operational hypersonic capabilities, many analysts in the West remain skeptical. Research on this technology has been progressing for decades, and it still remains challenging. For that reason, some see it as an expensive technological novelty that will not deliver a capability worth the investment made. This high cost and complexity also limit the potential for proliferation to middle and regional powers, such as North Korea and Iran.

HYPERSONIC WEAPON-DEFENSE SYSTEMS

One of the key value propositions offered by hypersonic weapons is that they will thwart virtually any current or near-term defensive measures. However, this has not prevented actors from attempting to develop defenses against such weapons. The challenges with countering hypersonic weapons are manifest; indeed, reliably intercepting ICBMs is already difficult to achieve—at its most crude, it is like trying to knock a ball out of the sky by throwing another ball at it. The inherent speed of hypersonic weapons makes this even more difficult—like trying to throw a ball at another that has been fired out of a cannon.

The further complication, of course, is the maneuverability of the hypersonic missile, 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, possibly within a few minutes.[13] The short timeframes mean near-ubiquitous surveillance would be necessary to respond to a surprise launch—and HGVs fly too low for most early-warning systems to detect.

Some experts believe that current systems, such as THAAD, can be adapted to be capable of intercepting HGVs in the terminal phase. Indeed, Russia announced in March 2020 that it had successfully destroyed more than one dozen Armavir and Favorit target missiles moving at hypersonic speeds with its S-400 air-defense system.[14] As with all self-reporting on hypersonic capabilities by the Russian state, few details of the conditions under which this was conducted were provided, and claims should be considered with significant skepticism. But, even if these systems are capable of intercepting the HGV, they are "point-defense" weapons that can only protect a comparatively small area.

The broader consensus is that the highest likelihood for success in interdiction would come during the initial launch/boost phase, before the missile has reached its ultimate speed and, in the case of HGVs, left the Earth's atmosphere. Theoretically, the F-35 has sensors capable of detecting the infrared signatures of a rocket launch, which could interdict during the boost phase. The 2019 Missile Defense Review also discussed the possibility of an airborne directed-energy system for interdiction in the boost phase, though this technology is a long way from full maturity.[15]

Despite the challenges of intercepting a HGV beyond the boost phase, Defense Advanced Research Projects Agency (DARPA) is seeking to develop a "glide breaker" system to do just that.[16] The US Missile Defense Agency (MDA) is also looking to develop a broader protective umbrella through a Hypersonic Defense Regional Glide Phase Weapon System.[17] Other HGV-defense systems are being developed for the Pentagon by Lockheed Martin (Valkyrie and Dart concepts), Boeing (Hypervelocity Interceptor), and Raytheon (SM-3 Hawk), while Raytheon is exploring a "non-kinetic" concept, likely to involve directed-energy systems.

None of these defenses would be of any use against scramjet-powered hypersonic cruise missiles or rail-gun rounds, as they remain in the atmosphere and are likely to be much smaller in size. The existing defenses against supersonic cruise missiles—Standard Missile-2, Standard Missile-6, Medium Extended Air Defense System (MEADS), and Evolved SeaSparrow Missile (ESSM)—may be developed to respond at greater speeds, but have not yet proven capable of doing so. There is unlikely to be any practicable defensive measure against rail guns.

Above all, however, is the challenge of detection, discrimination, and tracking. The speed of the weapon and its changing flight paths challenge current sensors. Only over-the-horizon (OTH) backscatter radars can detect hypersonic missiles before they cross the horizon, and low atmospheric travel makes them undetectable by current early-warning systems. Existing satellites could detect launch but could not track their glide phase.[18] Therefore, the first and most important step of creating a defensive measure is the creation of a "space sensor layer" while upgrading current surface missile-detection capabilities. Given the regional nature of the threat, integration and data sharing among partners on this highly sensitive topic—let alone command and control—will also be a key challenge, even before an interdiction capability can be considered. Sensors and battle-management systems may be the less exciting, but far more vital, component of a defensive system.

PULSE CHECK: TRACKING HYPERSONIC WEAPON DEVELOPMENT OF THE INDO-PACIFIC POWERS

As hypersonic weapons cover such a wide range of potential systems—what the Pentagon's director of defense research and engineering for modernization, Mark Lewis, calls "a suite of capabilities"—the specific hypersonic

13 Ryan Hilger, "Red Sky in Morning: Naval Combat at the Dawn of Hypersonics," *War on the Rocks,* February 28, 2019, *https://warontherocks.com/2019/02/red-sky-in-morning-naval-combat-at-the-dawn-of-hypersonics/.*

14 "S-400 Anti-Aircraft Missile Systems Strike Hypersonic Targets in Eastern Siberia Drills," *Russian News Agency*, March 27, 2020, *https://tass.com/defense/1136715*.

15 Samran Ali, "All the Secret (Or Not) Ways to Kill a Hypersonic Missile," *National Interest*, June 24, 2019, *https://nationalinterest.org/blog/buzz/all-secret-or-not-ways-kill-hypersonic-missile-64031.*

16 Michael Peck, "These DARPA Scientists Think They Can Knock Hypersonic Missiles Out of the Sky," *National Interest*, January 6, 2020, *https://nationalinterest.org/blog/buzz/these-darpa-scientists-think-they-can-knock-hypersonic-missiles-out-sky-110571*.

17 Paul Mcleary, "MDA Kickstarts New Way To Kill Hypersonic Missiles," *Breaking Defense*, December 18, 2019, *https://breakingdefense.com/2019/12/mda-kickstarts-new-way-to-kill-hypersonic-missiles/*.

18 Melanie Marlowe, "Hypersonic Threats Need and Offense-Defense Mix," *Defense News*, August 2, 2019, *https://www.defensenews.com/opinion/commentary/2019/08/02/hypersonic-threats-need-an-offense-defense-mix/*.

capabilities and technical expertise pursued by each state depend upon that state's military strategy.[19]

For example, as discussed below, the United States plans to deploy hypersonic systems as conventional weapons designed to rapidly penetrate enemy A2/AD bubbles. Thus, the US Department of Defense is prioritizing multi-domain (i.e., submarine-launched, ground-launched, and air-launched) hypersonic capabilities that can be deployed from both within and beyond contested environments. Russia, on the other hand, seeks to embed hypersonic weapons within its strategic deterrence mission in order to overcome new and perceived US defensive technology, and it is accordingly prioritizing means to deploy HGVs from ICBMs.[20] Indeed, "not all modernization programs are created equal," as each program is designed to serve the specific strategic purposes required by each respective state.[21]

Further, each state's geostrategic imperatives are shaped and informed by the regional context(s) in which it operates. In this case, the three nations most prominently pursuing hypersonic weapon technology—the United States, Russia, and China—as well as many other regional and middle powers, are located across the Indo-Pacific region.[22] This region also represents a number of international and strategic flashpoints, which makes it one of the most likely to see a conventional military contingency arise in the near- to mid-term future. As such, this primer and the wider research it supports focus predominantly on the implications of hypersonic weapons in that theater—though those implications can mostly be extrapolated to apply to other global contexts.

What follows, therefore, is a summary of the current status of hypersonic-weapons development among both the great powers and the United States' allies and partners in the Indo-Pacific region. As technological development accelerates, with potentially corresponding changes to military doctrine and strategic planning, the status of these programs will regularly evolve. As such, this summary is a "pulse check" at a single point in time, rather than an exhaustive analysis.

Tier I: The Great Powers

The United States

Current Strategy

The US Department of Defense is developing hypersonic weapons as part of its conventional prompt global strike (CPGS) program.[23] Since 2003, CPGS has "sought to provide the United States with the ability to strike targets anywhere on Earth with conventional weapons in as little as an hour, without relying on forward-based forces."[24] However, while the need for this mission set has been consistent across recent administrations, it has become far more salient now due to the return of great-power competition and related concerns about enemy A2/AD strategies, as explained by the 2017 National Security Strategy and the 2018 National Defense Strategy.[25]

The key challenge for the United States is that Russia and China have pursued asymmetric technologies and strategies that complicate US power projection, thereby preventing the United States from amassing sufficient combat power at the outset of a conflict, as it has done previously in operations like Desert Shield and Desert Storm. The common Russian and Chinese theory of victory purportedly rests on the *fait accompli* attack, which threatens "to overpower US allies and seize their territory while holding off US and other allied combat power," before extending their "A2/AD and defensive umbrella over these new gains."[26] As it is increasingly difficult to blunt and roll back adversarial attacks with forward-deployed US 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.[27] These strikes would prioritize command, control, communications, computers,

19 Patrick Tucker, "The US Wants to Intimidate China with Hypersonics, Once It Solves the Physics," *Defense One*, January 13, 2020, *https://www.defenseone.com/technology/2020/01/us-aims-intimidate-china-hypersonics-once-it-solves-physics/162408/*.

20 Kelley M. Sayler, *Hypersonic Weapons: Background and Issues for Congress*, Congressional Research Service, updated March 17, 2020, 4–14, *https://fas.org/sgp/crs/weapons/R45811.pdf*.

21 Matthew Kroenig and Christian Trotti, "Modernization as a Promoter of International Security: The Special Role of US Nuclear Weapons," in Aiden Warren and Philip M. Baxter, eds., *Nuclear Modernization in the 21st Century* (New York: Routledge, 2020).

22 France is the only prominent nation outside the Indo-Pacific developing hypersonic-weapons capabilities. It could be argued that France is also a Pacific power, as it retains numerous island dependencies across the region, but it is unlikely that the French would deploy such high-end capabilities to the region, and so they have not been included in the discussion.

23 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 1.

24 Amy F. Woolf, *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues,* Congressional Research Service, updated February 14, 2020, 2, *https://fas.org/sgp/crs/nuke/R41464.pdf*.

25 "National Security Strategy of the United States of America," White House, December 2017, *https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf*; "Summary of the 2018 National Defense Strategy of The United States of America," US Department of Defense, 2018, *https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf*.

26 Elbridge A. Colby, *Testimony Before the Senate Armed Services Committee: Hearing on Implementation of the National Defense Strategy, Senate Armed Services Committee*, January 2019, 3–4, *https://www.armed-services.senate.gov/imo/media/doc/Colby_01-29-19.pdf*.

27 Woolf, *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues,* 3–5.

Hypersonic weapons will likely feature prominently in the Indo-Pacific region. Here, a common hypersonic glide body (C-HGB) launches from the Pacific Missile Range Facility, Hawaii, on March 19, 2020 during a Department of Defense flight experiment. The US Navy and US Army joint executed the launch of the C-HGB, which flew at hypersonic speed to a designated impact point. Concurrently, the Missile Defense Agency (MDA) monitored and gathered tracking data from the flight experiment that will inform its ongoing development of systems designed to defend against adversary hypersonic weapons. *Source: US Navy photo https://www.pacom.mil/media/image-gallery.aspx?igphoto=2002267782*

intelligence, surveillance, and reconnaissance (C4ISR) networks and integrated air- and missile-defense (IAMD) systems, which "form the foundation of US competitors' anti-access/area denial strategies."[28]

US officials believe that hypersonic weapons may be the strategic solution to this problem. According to Vice Chairman of the Joint Chiefs of Staff General John Hyten, former commander of US Strategic Command, 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."[29] Indeed, 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 challenge.

These delivery mechanisms include submarines, which can operate stealthily within contested environments, as well as long-range ground-launched systems, which can be deployed from beyond those environments. Consequently, the US Army, Navy, and Air Force are all considering how to develop new operational concepts that harness the unique opportunities presented by these future weapons. The Army, for example, plans to integrate hypersonic weapons into its Long-Range Precision Fires (LRPF) capability set, which could be useful for penetrating and disintegrating A2/AD bubbles in accordance with Multi-Domain Operations doctrine.[30]

28 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 4.

29 Ibid., 2.

30 Jen Judson, "US Army to Demo Precision Strike, Hypersonics, Ramjet Capabilities in Just a Few Years," *Defense News*, March 20, 2018, *https://tinyurl.com/yxuez2d3*; "The US Army in Multi-Domain Operations 2028, TRADOC Pamphlet 525-3-1," US Army Training and Doctrine Command, December 2018, *https://tinyurl.com/ya7xa9nw*.

A B-52 from the 419th Flight Test Squadron out of Edwards Air Force Base, California, carries a prototype of the AGM-183A Air-Launched Rapid Response Weapon, or ARRW, for its first captive carry flight on June 12, 2019. *Source: US Air Force photo by Christopher Okula https://www.edwards.af.mil/News/Article/1884289/b-52-continues-mothership-role-during-hypersonic-test/. This image was modified with a red circle applied over the ARRW missile.*

Given the variety of conventional mission sets and delivery mechanisms considered by the Pentagon, this "multi-faceted approach sets the US hypersonic effort apart from its competitors," who have often tailored their programs more narrowly toward nuclear deterrence.[31] Therefore, it appears that US hypersonic weapons would have more wartime applications. Additionally, by threatening to defeat the primary means of potential Russian and Chinese aggression, US hypersonic weapons would also serve as a peacetime strategic deterrent (i.e., deterrence by denial). However, it should be noted that some experts worry about the implications for strategic stability due to the incredible speed of these weapons, which compresses decision-making and, therefore, complicates deterrence.[32]

Technical Capability

The US Department of Defense is dedicating its resources to several hypersonic programs across its military services, in order to develop various multidomain applications. For now, funding resides within the research, development, test, and evaluation (RDT&E) appropriations title for purposes of prototyping, while procurement and fielding of these systems will demand more time.[33] Since the United States is solely planning to arm its hypersonic systems with conventional warheads, these "hypersonic weapons will likely require greater accuracy and will be more technically challenging to develop than nuclear-armed Chinese and Russian systems."[34]

31 Tucker.

32 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 16-17; Woolf, *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues,* 2–3.

33 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 5.

34 Ibid., 4.

While the Army, Navy, and Air Force are developing their own capabilities, the Army and Navy intend to use the Sandia National Laboratories' Common Hypersonic Glide Body (C-HGB). This common HGV is based on the Army's successful Alternate Re-Entry System prototype, which can fly at Mach 6.[35] The Navy will specifically pair it with a submarine-launched booster system as part of its Intermediate Range Conventional Prompt Strike Weapon (IRCPS); it conducted a successful test of this weapon in 2017.[36] Meanwhile, in order to develop its Long-Range Hypersonic Weapon (LRHW), the Army will pair C-HGB with a two-stage, ground-launched booster system to penetrate A2/AD at great distances.[37] The Air Force originally had two hypersonic programs: the rocket-powered and Global Positioning System (GPS)-guided Hypersonic Conventional Strike Weapon (HCSW) carrying C-HGB; and the Air-Launched Rapid Response Weapon (ARRW) carrying the Tactical Boost Glide (TBG) vehicle, which the Air Force is jointly developing with the DARPA.[38] However, due to constraints in the fiscal year 2021 (FY21) budget, the Air Force was forced to cut one of its two programs, and it chose to cut HCSW. The Air Force prefers ARRW because it carries the more unique TBG vehicle, whereas HCSW would have relied on the C-HGB, which the other services are already developing.[39] DARPA is also developing an Operational Fires program, which will use TBG to penetrate air defenses, while working with the Air Force on a Hypersonic Air-breathing Weapon Concept (HAWC) to develop a hypersonic cruise missile in the future.[40]

In order to underpin this technical capability, the United States maintains dozens of hypersonic test facilities, but none of them are capable of generating speeds beyond Mach 10.[41]

Near-Term Forecast

Due to Russian and Chinese pursuit of hypersonic weapons, there is a much greater focus on this weapons system within the US policymaking community. Indeed, along with other emerging technologies like artificial intelligence, autonomous systems, and fifth-generation (5G) networks, the Pentagon perceives hypersonic weapons as a means to expand and reassert the US competitive advantage vis-à-vis great-power competitors.[42] However, due to the imperative of accuracy and the distribution of funding across multiple different programs, "the United States is unlikely to field an operational system before 2022."[43]

Given the United States' interest in multidomain applications for hypersonic weapons, it will likely continue to prioritize submarine-launched, ground-launched, and air-launched HGVs. The Navy will test its IRCPS prototype in 2020 and 2022, the Army will test LRHW in 2023, and the Air Force will test ARRW through 2022. Hypersonic cruise missiles (i.e., through HAWC) and hypersonic missile defenses will require even more time, though the HAWC may transition more quickly due to its simpler structure.[44]

Russia

Current Strategy

For the Kremlin, hypersonic weapons are primarily a means to bolster Russia's second-strike nuclear capability, thereby maintaining a state of MAD vis-à-vis the United States. Russian officials have long feared that advances in US offensive missiles and missile-defense technology may eventually produce a first-strike capability. Specifically, they believe that "the United States could conduct a successful first strike with conventional missiles and then mop up Russia's ragged retaliatory strikes with advanced missile defenses."[45] While their fears are exaggerated, they perceive this threat as existential. Therefore, the Kremlin seeks a set of capabilities that can hedge against current and future US advances, thereby ensuring Russia's nuclear deterrent.

35 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 5; Woolf, *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues,* 17–18.

36 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 5; Zachary Keck, "Is The US Navy Planning To Put Hypersonic Missiles on Submarines," *National Interest*, October 11, 2019, *https://nationalinterest.org/blog/buzz/us-navy-planning-put-hypersonic-missiles-submarines-87631.*

37 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 6.

38 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 6–7; Woolf, *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues,* 17–18; Joseph Trevithick, "B-52 Bomber Flies For the First Time With New Hypersonic Missile Under Its Wing," *Drive*, June 13, 2019, *https://www.thedrive.com/the-war-zone/28518/a-b-52-bomber-flies-for-the-first-time-with-new-hypersonic-missile-under-its-wing*.

39 Valerie Insinna, "US Air Force Kills One of its Hypersonic Weapons Programs," *DefenseNews*, February 10, 2020, *https://www.defensenews.com/smr/federal-budget/2020/02/10/the-air-force-just-canceled-one-of-its-hypersonic-weapons-programs/*; Woolf, *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues,* 18.

40 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 7.

41 Ibid., 9.

42 "Defense Budget Overview: Irreversible Implementation of the National Defense Strategy," United States Department of Defense, February 2020, 1–8, *https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2021/fy2021_Budget_Request_Overview_Book.pdf*.

43 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 1.

44 Ibid., 5-9.

45 Matthew Kroenig, Mark Massa, and Christian Trotti, *Russia's Exotic Nuclear Weapons and Implications for the United States and NATO*, Atlantic Council, March 6, 2020. *https://www.atlanticcouncil.org/wp-content/uploads/2020/07/Russias-Exotic-Nuclear-Weapons.pdf*

The Russian *Kinzhal* is an air-launched hypersonic ballistic missile that can be deployed from the MiG-31 and Su-34 fighters. *Source: Wikimedia Commons https://commons.wikimedia.org/wiki/File:2018_Moscow_Victory_Day_Parade_66.jpg*

Accordingly, Russian hypersonic weapons are primarily a strategic capability. Rapid and maneuverable nuclear-armed hypersonic weapons embody "an assured means of penetrating US missile defenses and restoring its [the Kremlin's] sense of strategic stability."[46] This contributes to Russian deterrence by retaliation, as opposed to the United States' plan to integrate hypersonic systems as conventional weapons with tactical and operational applications in wartime. Accordingly, as explained below, the Russians plan to deploy nuclear-armed HGVs on ICBMs. In their view, doing so would allow them to improve the efficacy of their nuclear deterrent, possibly without increasing their arsenal beyond New Strategic Arms Reduction Treaty (New START) limits.[47] Additionally, when presented alongside newer Russian capabilities like the *Burevestnik* nuclear-armed, nuclear-powered cruise missile and the Poseidon nuclear-armed underwater drone, Russian hypersonic weapons may provide sufficient diplomatic leverage to compel the United States to renew New START.[48] However, given the Donald Trump administration's willingness to withdraw from the Intermediate-Range Nuclear Forces (INF) Treaty in 2019, it is unlikely that the United States will be coerced into renewing New START if Russian terms are otherwise unacceptable. Rather, the Russian pursuit of hypersonic weapons has only spurred the United States to invest more substantially in its own programs.

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 US carrier strike groups, as well as sea-based and land-based missile-defense systems, thereby supplementing its A2/AD strategy.[49] Standoff capabilities are essential for Russia's regional force posture, and hypersonic weapons will likely be an important facet of the US-Russia competition between penetrating A2/AD on the one hand, and bolstering it on the other.

Technical Capability

According to the Kremlin's statements in December 2019, Russia may have already become the first world power to deploy an HGV.[50] However, President Vladimir Putin has often boasted that Russia is leading the world in hypersonic capabilities, and his claims have been met with skepticism

46 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 10.

47 Kroenig et al., *Russia's Exotic Nuclear Weapons and Implications for the United States and NATO*, 6.

48 Julian E. Barnes and David E. Sanger, "Russia Deploys Hypersonic Weapon, Potentially Renewing Arms Race," *New York Times*, December 27, 2019, *https://www.nytimes.com/2019/12/27/us/politics/russia-hypersonic-weapon.html*.

49 Jill Hruby, *Russia's New Nuclear Weapon Delivery Systems: An Open-Source Technical Review*, Nuclear Threat Initiative, November 2019, 20–24, *https://media.nti.org/documents/NTI-Hruby_FINAL.PDF*.

50 Barnes and Sanger, "Russia Deploys Hypersonic Weapon, Potentially Renewing Arms Race."

in the past.[51] The likely crash of Russia's nuclear-powered *Burevestnik* missile in 2019, as well as the Kremlin's relative comfort with "rushing weapons systems into the field at a pace that would not be possible in the United States," suggests that Russian hypersonic systems may not be as advanced as Putin claims.[52]

For its strategic-deterrence mission set, Russia is developing the *Avangard* hypersonic boost-glide vehicle. This HGV will eventually be deployed on the *Sarmat* ICBM when it is ready, but for now it will be fitted to the existing SS-19 Stiletto ICBM. It can be conventional or nuclear armed, though its primary military function will likely be to carry nuclear weapons. During a test in December 2018, this HGV was reported to achieve speeds above Mach 20.[53] While some US experts do not expect Russia to field this weapon system until 2020 at the earliest, this is apparently the system that was already deployed in December 2019, according to the Kremlin.[54]

Russia has also developed the *Kinzhal*, an air-launched hypersonic ballistic missile that can be deployed from the MiG-31 and Su-34 fighters. It is working to eventually deploy this missile on the Tu-22M3 strategic bomber.[55] This dual-capable missile can strike targets two thousand kilometers away at speeds between Mach 5 and Mach 10, and while it "has fins to provide maneuverability…its trajectory is largely aeroballistic."[56] It is designed to target missile-defense installations and carrier strike groups as part of Russia's A2/AD strategy. Further augmenting this strategy is the *Tsirkon* ship-launched hypersonic cruise missile, which will be powered by a solid-fueled first phase and a scramjet second phase. The missile will be capable of travelling between Mach 5 and Mach 6 up to five hundred kilometers, and it is designed "to target missile defense installations, decision centers, and high-value assets from a safe distance without risk of interception, because of its speed and maneuverability over short ranges."[57] Russia has successfully tested both the *Kinzhal* and the *Tsirkon* in late 2019 and early 2020.[58] The *Kinzhal* is reportedly closest to deployment.[59] The *Tsirkon* likely possesses the longest timeline of these systems, and may not be deployed on a *Kirov*-class battle cruiser until 2022, but the Kremlin is already expediting test launches from submarines.[60]

Near-Term Forecast

While it is not clear if Russia is truly the world's hypersonic leader—primarily since it is difficult to establish a common definition of leadership in a set of technologies that can be so diversely applied—it is certainly close to achieving an operational HGV and hypersonic ballistic missile, if it has not already.[61]

Given the United States' assured second-strike capability, and for reasons stated earlier, it may not fear a Russian nuclear-armed HGV in the near-term. However, Russia's *Kinzhal* hypersonic ballistic missile and its longer-term *Tsirkon* hypersonic cruise missile bear significant implications for the United States' ability to defeat enemy A2/AD defenses. If nuclear-armed, these systems may also supplement Russia's escalate-to-deescalate nuclear strategy, thereby providing coercive leverage over the United States, NATO, and other European countries.[62] Lastly, the threat of Russian nuclear-armed hypersonic weapons may complicate the ability of decision-makers to distinguish between conventional and nuclear hypersonic weapons, perhaps undermining strategic stability.

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51 Nathan Hodge, "Putin Claims Russia is world leader on hypersonic weapons," CNN, December 25, 2019, *https://www.cnn.com/2019/12/25/europe/putin-russia-weapons-intl/index.html*.

52 Kroenig et al., *Russia's Exotic Nuclear Weapons and Implications for the United States and NATO*, 4; David E. Sanger and Andrew E. Kramer, "US Officials Suspect New Nuclear Missile in Explosion That Killed 7 Russians," New York Times, August 12, 2019, *https://www.nytimes.com/2019/08/12/world/europe/russia-nuclear-accident-putin.html*.

53 Hruby, *Russia's New Nuclear Weapon Delivery Systems: An Open-Source Technical Review*, 9–10.

54 Barnes and Sanger, "Russia Deploys Hypersonic Weapon, Potentially Renewing Arms Race."

55 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 11.

56 Hruby, *Russia's New Nuclear Weapon Delivery Systems: An Open-Source Technical Review*, 9.

57 Ibid., 10.

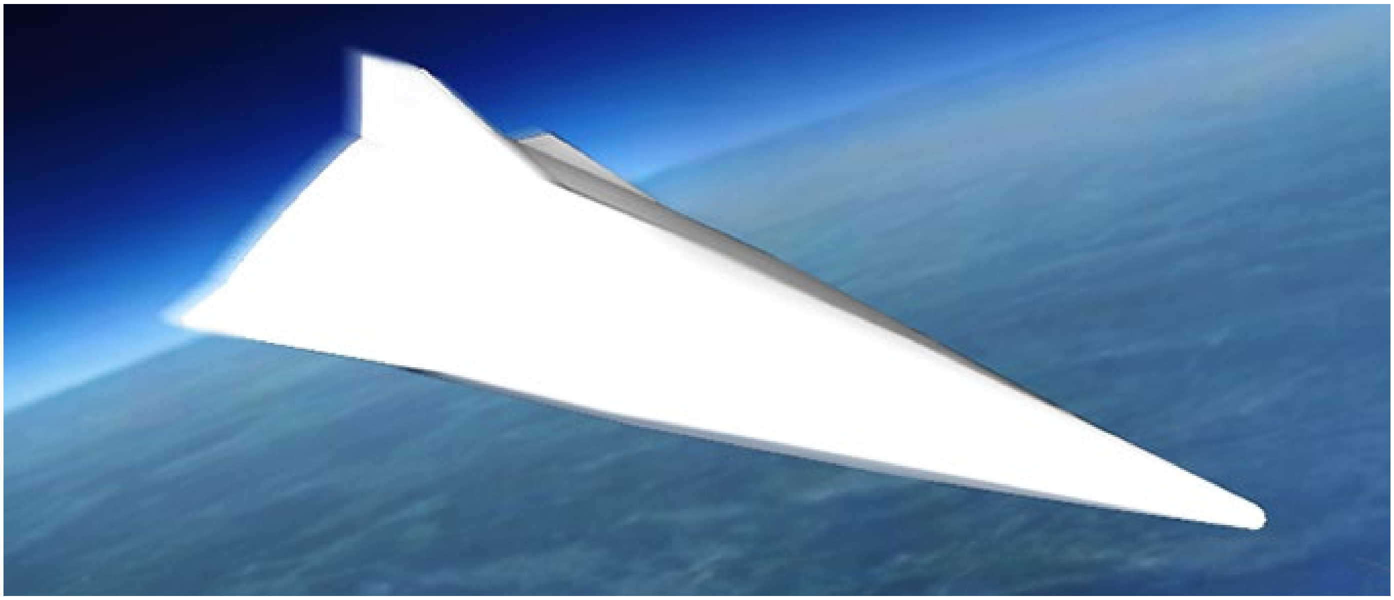
58 Shaan Shaikh, "Russia Tests Kinzhal Missile in Arctic," Center for Strategic and International Studies, December 2, 2019, *https://missilethreat.csis.org/russia-tests-kinzhal-missile-in-arctic/*; Alexander Marrow, "Russia Conducts First Ship-Based Hypersonic Missile Test: TASS," Reuters, February 27, 2020, *https://www.reuters.com/article/us-russia-military-missiles/russia-conducts-first-ship-based-hypersonic-missile-test-tass-idUSKCN20L2CL*.

59 Julian Cooper, "Russia's Invincible Weapons: Today, Tomorrow, Sometime, Never?" University of Oxford, May 2018, *http://static1.squarespace.com/static/55faab67e4b0914105347194/t/5b0eb1b203ce644a398267ef/1527689654381/Russia%27s+Invincible+Weapons.pdf*.

60 Hruby, *Russia's New Nuclear Weapon Delivery Systems: An Open-Source Technical Review*, 10; Franz-Stefan Gady, "Russian Navy to Speed up Test Launches of Tsirkon Hypersonic Missile," *The Diplomat*, April 1, 2020, *https://thediplomat.com/2020/04/russian-navy-to-speed-up-test-launches-of-tsirkon-hypersonic-missile/*.

61 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 1; Hruby, *Russia's New Nuclear Weapon Delivery Systems: An Open-Source Technical Review*, 9-10; Barnes and Sanger, "Russia Deploys Hypersonic Weapon, Potentially Renewing Arms Race."

62 Matthew Kroenig, A Strategy for Deterring Russian Nuclear De-Escalation Strikes, Atlantic Council, April 2018, *https://www.atlanticcouncil.org/wp-content/uploads/2018/04/Nuclear_Strategy_WEB.pdf*.



The Chinese DF-ZF is believed to be highly maneuverable and capable of traveling up to 1,200 miles. *Source: Wikimedia Commons https://commons.wikimedia.org/wiki/File:Chinese_Hypersonic_Gliding_Vehicle.jpg*

China

Current Strategy

Beijing shares the Kremlin's fears of US missile defenses and other technological advances. Specifically, the Chinese hypersonic program "is largely catalyzed by concerns that US advanced missile defense systems, particularly and most recently THAAD, are severely undermining if not abrogating China's strategic and conventional nuclear deterrent."[63] China is also concerned that "US hypersonic weapons could enable the United States to conduct a preemptive, decapitating strike on China's nuclear arsenal and supporting infrastructure."[64] This may be a product of Beijing's longstanding "minimum deterrent" posture, whereby it has not followed the United States and Russia in building a superpower nuclear arsenal in accordance with its size, power, and prestige.[65] Consequently, its second-strike capability is not as robust as that of the other two great powers, and China may, therefore, need hypersonic weapons to improve that capability. As a rising China expands the facets of its military competition with the United States, it may feel upward pressures upon both the capability and capacity of its strategic arsenal.

Perhaps more pressing for China is the regional security context.[66] In addition to threatening China's strategic nuclear arsenal, US missile defenses and new offensive technologies deployed in the Asia-Pacific complicate Chinese A2/AD and power-projection capabilities.[67] Shorter- and intermediate-range hypersonic weapons could supplement China's extensive missile capabilities, thereby providing a range of retaliatory, escalatory, and coercive options in peacetime or wartime. Accordingly, even if China, like Russia, is concerned about a potential existential threat to its nuclear arsenal, it is apparently prioritizing hypersonic capabilities that can bolster its regional A2/AD strategy.

Technical Capability

In accordance with its regional strategic outlook and A2/AD strategy, China is developing the DF-ZF HGV, which may be operational in 2020. This HGV is believed to be highly maneuverable and capable of traveling up to 1,200 miles. Beijing will primarily deploy it on the DF-17 medium-range ballistic missile, which was tailored to carry it and which has a range of 1,000–1,500 miles.[68] While the status of the DF-17 is unclear, the Chinese military appears to have

63 Tate Nurkin, *China's Advanced Weapons Systems,* Jane's, May 12, 2018, 10, *https://www.uscc.gov/sites/default/files/Research/Jane%27s%20by%20IHS%20Markit_China%27s%20Advanced%20Weapons%20Systems.pdf.*

64 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 12.

65 Matthew Kroenig, *The Logic of American Nuclear Strategy: Why Strategic Superiority Matters* (New York: Oxford University Press, 2018); Eric Heginbotham et al., *China's Evolving Nuclear Deterrent: Major Drivers and Issues for the United States,* RAND, *https://www.rand.org/content/dam/rand/pubs/research_reports/RR1600/RR1628/RAND_RR1628.pdf.*

66 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 13.

67 Nurkin, *China's Advanced Weapon Systems,* 10.

68 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 13.

exhibited sixteen of these missiles during a parade to celebrate the seventieth anniversary of the People's Republic of China in October 2019, and they may be deployed as early as 2020.[69] Beijing may also deploy HGVs on existing DF-21 or DF-26 missiles to underpin its regional A2/AD posture.[70]

In pursuit of additional technological innovations, China has successfully tested the Xing Kong-2, "a nuclear-capable hypersonic vehicle prototype…[which] is a 'waverider' that uses powered flight after launch and derives lift from its own shockwaves."[71] This capability can travel at speeds up to Mach 6, but it may not be operational until 2025.

In order to threaten the US mainland and ensure its own nuclear second-strike capability, China is also developing the DF-41 ICBM, which could carry a conventional or nuclear HGV, or alternatively a more traditional multiple independently targetable reentry vehicle (MIRV)-capable payload of ten warheads.[72]

China has worked extensively to build the necessary infrastructure for its hypersonic-weapons program. Its wind tunnels can achieve speeds of up to Mach 15, and they even may be able to achieve Mach 25 this year.[73] As a result, in March 2018, Under Secretary of Defense for Research and Engineering Michael Griffin claimed that "China has conducted 20 times as many hypersonic tests as the United States."[74]

Near-Term Forecast

Like Russia, China may deploy a hypersonic weapon as early as 2020. However, it "has reportedly not made a final determination as to whether its hypersonic weapons will be nuclear- or conventionally armed—or dual-capable," which is a significant decision for its force posture and for appropriate US countermeasures.[75] As with the Russian threat, the United States should be more concerned about the application of Chinese hypersonic weapons to China's regional A2/AD capabilities, rather than the global nuclear balance of power.

Tier II: US Allies and Partners in the Indo-Pacific

Australia

Current Policy and Future Strategy

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. Accordingly, as demonstrated in its recent 2020 Defence Strategic Planning Update, Australia is prioritizing longer-range strike weapons and related capabilities "to hold adversary forces and infrastructure at risk further from Australia."[76] In the air domain, this may include hypersonic weapons.[77]

The Australian Defense Science and Technology (DST) group is working to develop hypersonic flight through scramjets, an effort applicable to hypersonic transport of people and cargo, as well as explosive payloads.[78] Some analysts claim that Australia's main interest in hypersonic flight is for commercial flight, although the Australian Air Force has also contemplated manned and unmanned aircraft for strike and ISR purposes.[79]

Technical Capability

Australia's DST is working with the US Air Force Research Lab, the University of Queensland, and Boeing on the HIFiRE project, designed "to further the fundamental scientific understanding of hypersonic flight, including related

69 James Acton, "China's Ballyhooed New Hypersonic Missile isn't Exactly a Game-Changer," *Washington Post*, October 4, 2019, *https://www.washingtonpost.com/opinions/2019/10/04/chinas-ballyhooed-new-hypersonic-missile-isnt-exactly-game-changer/*; Sayler, *Hypersonic Weapons: Background and Issues for Congress*, 13.

70 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 13.

71 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 13; Jessie Yeung, "China Claims to Have Successfully Tested its First Hypersonic Aircraft," CNN, August 7, 2018, *https://www.cnn.com/2018/08/07/china/china-hypersonic-aircraft-intl/index.html*.

72 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 13; "2018 Report to Congress of the US-China Economic and Security Review Commission," One Hundred Fifteenth Congress of the United States of America, November 2018, *https://www.uscc.gov/sites/default/files/annual_reports/2018%20Annual%20Report%20to%20Congress.pdf*; Bill Bostock, "China Used a Massive Military Parade to Unveil a Supersonic, Nuclear Capable Missile that Could Get Around the US Missile-Defense System," Business Insider, October 1, 2019, *https://www.businessinsider.com/china-unveils-dongfeng-41-nuclear-ready-missile-threaten-us-2019-10*.

73 Sayler, *Hypersonic Weapons: Background and Issues for Congress,* 13–14.

74 Ibid., 13.

75 Ibid., 12.

76 "2020 Defence Strategic Update," Australian Government Department of Defence, 2020, *https://www.defence.gov.au/StrategicUpdate-2020/docs/2020_Defence_Strategic_Update.pdf, 27*.

77 Ibid., 38.

78 "Hypersonic Flight," Australian Government, Department of Defence, Science and Technology, accessed February 17, 2020, *https://www.dst.defence.gov.au/projects/hypersonic-flight*.

79 Clive Williams, "Global hypersonic Arms Race Gains Speed," Canberra Times, July 1, 2019, *https://www.canberratimes.com.au/story/6274658/global-hypersonic-arms-race-gains-speed/*.

technologies in propulsion, combustion, materials, sensors, guidance and control."[80] The United States has contributed $54 million to joint efforts in hypersonic systems.[81] HIFiRE has been researching hypersonic technologies for more than a decade, conducting an important trial in 2012 verifying the performance of a scramjet engine at Mach 8 in a descent from a sounding rocket.[82] DSTG completed a successful test of the HiFIRE 4 vehicle, representing a high degree of sophistication in surviving and maneuvering at hypersonic speeds.[83] The most recent launch of the HiFIRE series, HiFIRE 8, achieved Mach 8 in a scramjet configuration.[84]

One of Australia's greatest assets for the competition to develop hypersonic technology is its research and testing capabilities. Australia's Woomera Test Range contains the largest land-based missile-test facilities in the world (roughly the size of Pennsylvania), and the nation possesses six hypersonic wind tunnels, capable of simulating a maximum of Mach 30.[85] Australia also has ongoing work on using hypersonic boosters for reusable spaceflight.[86]

Near-Term Forecast

Australia's 2016 defense white paper envisions hypersonic weapons being introduced into Australia's region by 2035.[87] Australia has no programs of record for militarizing the capabilities that it is researching with the United States. Government publications constantly stress the potential civilian applications of hypersonic flight, though this is in large part because the smaller economies of scale in Australia require dual-purpose application to justify the significant investment required.

India

Current Policy and Future Strategy

While India is not currently deploying hypersonic weapons, it has advanced its ongoing research and development due, in part, to collaboration with Russia on the BrahMos series of missiles. The first BrahMos missile—a supersonic, ramjet-powered cruise missile—can be launched from air or sea and has been exported, including to Vietnam.[88] Russia and India are collaborating on the BrahMos II, a follow-on missile designed to fly at speeds up to Mach 7 using a scramjet.[89]

For India, the short-range hypersonic missiles would be especially valuable due to their maneuverability for striking targets otherwise obscured by mountains in contingencies involving Pakistan and China.[90]

Technical Capability

While the BrahMos project is 50.5-percent owned by India, the missile relies on design and key components—including the ramjet itself—from Russia. It is unclear if India has been able to localize all of the skills and knowledge to produce supersonic missiles on its own, and the same could be said of whatever product results from the BrahMos II hypersonic effort.[91] The most important indigenous hypersonic capability in India is the Hypersonic Technology Demonstrator Vehicle (HSTFV), a scramjet demonstrator developed by India's Defence Research and Development Organization.[92] Apparently, the first HSTFV test was incomplete in June 2019 due to the failure of an Indian Agni-I ballistic missile to reach the proper altitude.[93]

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80 "Hypersonic Flight," Australian Government,

81 "HIFiRE Program," Australian Government, Department of Defense, Science and Technology, accessed February 17, 2020, *https://www.dst.defence.gov.au/partnership/hifire-program.*

82 Michael Smart, "Flight Experiment Goes Boldly Forth to Advance New Technology," University of Queensland, December 14, 2012, *https://www.uq.edu.au/news/article/2012/12/flight-experiment-goes-boldly-forth-advance-new-technology*.

83 Kyle Mizokami, "The US and Australia Conducted a Secretive Hypersonic Missile Test," *Popular Mechanics*, July 18, 2017, *https://www.popularmechanics.com/military/research/a27384/us-australia-hypersonic-missile-test/*; "Australian Engineers Complete Hypersonic Test Flight," Engineers Australia, accessed February 17, 2020, *https://www.engineersaustralia.org.au/News/australian-engineers-complete-hypersonic-test-flight*.

84 Hallen and Spencer, "Hypersonic Air Power."

85 Kellie Tranter, "Australia's Appetite for Hypersonics," John Menadue, October 15, 2019, *https://johnmenadue.com/kellie-tranter-australias-appetite-for-hypersonics/*.

86 Richard H. Speier, et al., "Hypersonic Missile Nonproliferation: Hindering the Spread of a New Class of Weapons," RAND, 2017, *rand.org/pubs/research_reports/RR2137.html*, p. 58.

87 "2016 Defence White Paper," Australian Government, Department of Defence, 50, *https://www.defence.gov.au/WhitePaper/Docs/2016-Defence-White-Paper.pdf*.

88 "BrahMos," Missile Threat Project, Center for Strategic and International Studies, last updated June 15, 2018, *https://missilethreat.csis.org/missile/brahmos/*.

89 Speier, et al., "Hypersonic Missile Nonproliferation," 24.

90 "BrahMos II," Missile Defense Advocacy Alliance, accessed February 17, 2020, *https://missiledefenseadvocacy.org/missile-threat-and-proliferation/missile-proliferation/russia/brahmos-ii/*.

91 "BrahMos to attain 76% localisation in six months," *Hindu Business Line*, May 6, 2018, *https://www.thehindubusinessline.com/news/national/brahmos-to-attain-76-localisation-in-six-months/article23793579.ece*.

92 Samran Ali, "Hypersonic Weapons Affect South Asia Too," *Arms Control Association*, August 2019, *https://www.armscontrol.org/act/2019-07/features/hypersonic-weapons-affect-south-asia-too*.

93 Manu Pubby, "India Tests Hypersonic Demonstrator Vehicle Launched from Agni I Platform," *Economic Times*, June 13, 2019, *https://tinyurl.com/y3vw2lbc*

Near-Term Forecast

BrahMos II is expected to reach initial operating capability by 2025.[94] India's completely indigenous efforts, outside of the BrahMos collaboration with Russia, are less far advanced and unlikely to be important in the near term.

Japan

Current Policy and Future Strategy

In August 2018, Japan released its highest-ever defense budget, with a medium-term focus on hypervelocity weapons.[95] "The 2019 budget request included ¥6.4bn (US$58 million) for research and development on a hypersonic scramjet-powered cruise missile and a ¥13.8bn (US$126m) pledge for the development of a Hyper Velocity Gliding Projectile (HGVP)."[96]

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.[97] This was confirmed in March 2020 when the Japan Defense Ministry released more details about its hypersonic programs and confirmed its plans to build a hypersonic scramjet and boost-glide missile in the 2030 timeframe.

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.[98] These missiles will be deployed to Japan's southernmost bases to allow force projection into remote islands without necessarily deploying the Self-Defense Force. In order to meet this requirement, Japan has planned for its missiles to have a roughly two-hundred-mile range.[99]

Once it acquires these missiles, Japan envisions using them from standoff range to negate offensive systems that hold Japanese Self-Defense Force (SDF) personnel at risk.[100] The armor-piercing anti-ship missiles will be used to defend against the invasion of remote islands, almost certainly referring to a potential Chinese seizure of the disputed Senkaku islands.[101]

Technical Capability

The Japanese have outlined four key technological barriers that Japan will need to address before it can field hypersonic weapons. For fire control, Japan requires both GPS signals that are resistant to jamming and alternate means of position, navigation, and timing (PNT); as a backup, Japan is developing inertial guidance. For guidance, Japan must invent novel infrared signature-discrimination sensors that can operate despite the enormous heat that the missile will generate as it moves through the air. Japan must develop an advanced solid rocket motor. Finally, Japan must develop the airframe itself and the explosively formed penetrator as the payload.[102] Other currently unavailable capabilities are the ability to efficiently combust jet fuel during hypervelocity flight and heat-resistant materials.[103]

Near-Term Forecast

While Japan has committed to delivering its first hypersonic weapon by 2030, officials have repeatedly stressed that the timeline is flexible and that the weapons could be available as early as 2026.[104] Japan intends to complete testing between 2023 and 2035.[105]

94 "BrahMos II," Missile Defense Advocacy Alliance.

95 Alina Ragge, "Japan: Plans for Electronic-Warfare and Hypersonic Capabilities," *Military Balance Blog*, International Institute for Strategic Studies, December 3, 2018, *https://www.iiss.org/blogs/military-balance/2018/12/japan-plans-hypersonic-capabilities*.

96 Ibid.

97 Stew Magnuson, "Japan Maps Out Vision for Hypersonic Vehicles," *National Defense*, November 18, 2019, *https://www.nationaldefensemagazine.org/articles/2019/11/18/japan-maps-out-vision-for-hypersonic-vehicles*.

98 Mike Yeo, "Japan Unveils its Hypersonic Weapons Plans," *Defense News*, March 13, 2020, *https://www.defensenews.com/industry/techwatch/2020/03/13/japan-unveils-its-hypersonic-weapons-plans/*; Kosuke Takahashi, "Japan Developing New Anti-Surface Warheads for Future Hypersonic Missiles," *Jane's Defence Weekly*, March 12, 2020, *https://www.janes.com/article/94850/japan-developing-new-anti-surface-warheads-for-future-hypersonic-missiles*; David Axe, "Japan's New Mach 5 Carrier-Killer Missile Is A Direct Response To China," National Interest, March 19, 2020, *https://nationalinterest.org/blog/buzz/japans-new-mach-5-carrier-killer-missile-direct-response-china-134427*.

99 Masaya Kato, "Japan Plans to Deploy Hypersonic Missiles and Upgraded Carrier," *Nikkei Asian Review*, December 5, 2018, *https://asia.nikkei.com/Politics/Japan-plans-to-deploy-hypersonic-missiles-and-upgraded-carrier*.

100 Magnuson, "Japan Maps Out Vision for Hypersonic Vehicles."

101 "Defense of Japan: Digest," Ministry of Defense, 2019, 14, *https://www.mod.go.jp/e/publ/w_paper/pdf/2019/DOJ2019_Digest_EN.pdf*.

102 Magnuson, "Japan Maps Out Vision for Hypersonic Vehicles."

103 Michael Peck, "Get Ready, China: Japan is Joining the Hypersonic Missile Club," *National Interest*, October 6, 2018, *https://tinyurl.com/y4bh4hk7*.

104 Ragge, "Japan: Plans for Electronic-Warfare and Hypersonic Capabilities."

105 Peck, "Get Ready, China: Japan is Joining the Hypersonic Missile Club."

Singapore

Current Policy and Future Strategy

Singapore has held talks with India about acquiring the Mach 3 BrahMos I missile.[106] Otherwise, Singapore has expressed no interest in hypersonic weapons to date.

Technical Capability

Singapore has shown only academic interest in hypersonic capabilities.[107]

Near-Term Forecast

Singapore has neither the capacity nor the strategic intention to develop hypersonic missiles.

South Korea

Current Policy and Future Strategy

Reports from the first decade of the 2000s suggested that South Korea was developing the Haeseong-2, a ramjet-powered hypersonic cruise missile. There has been no recent public discussion of a South Korean missile.[108]

Technical Capability

While research into hypersonic aerodynamics is ongoing at South Korean universities, the nation lacks appropriate wind tunnels to develop a hypersonic device.[109]

Near-Term Forecast

Hypersonic weapons do not appear to be a priority for South Korea, and the country lacks the infrastructure to build toward an indigenous hypersonic-weapons program in the near future.

Taiwan

Current Policy and Future Strategy

Taiwan's defense white paper mentioned hypersonic technologies only in relation to the threat from the mainland Chinese development of hypersonic missiles.[110] However, the report emphasizes dominance in littoral strike, implying that hypersonic weapons may well be of interest to the Taiwanese in the future.[111]

Technical Capability

A December 2019 *National Interest* article characterized the Taiwanese missile *Yun Feng* as hypersonic, although the missile is reputed to reach only supersonic speeds, perhaps of 1,030 meters per second (2,304 miles per hour; Mach 5 is 3,806 miles per hour).[112] Reportedly, this ground-launched land-attack cruise missile uses a solid-fuel rocket booster in combination with a ramjet.[113] While Taiwan has subsonic and supersonic wind tunnels, it has no hypersonic wind tunnels.[114]

Near-Term Forecast

While Taiwan does not currently have any publicly acknowledged programs for building hypersonic weapons, the island republic will likely continue to enhance its capacity to produce the systems at the heart of a functioning hypersonic enterprise. Primarily, Taiwan is developing its capacity to build scramjets, a key component of any air-launched hypersonic missile with applicability to cruise missiles in the supersonic speed range as well.[115]

SECURITY IMPLICATIONS FOR THE INDO-PACIFIC REGION

What does this mean for the Indo-Pacific? While the ultimate strategic implications of hypersonic weapons will only

106 Ibid, 71.

107 Paige P. Cone, Assessing the Influence of Hypersonic Weapons on Deterrence (Maxwell Air Force Base, Alabama: Center for Strategic Deterrence Studies, June 2019), *https://media.defense.gov/2019/Sep/25/2002187108/-1/-1/0/59HYPERSONICWEAPONS.PDF*.

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

109 Ibid., 89.

110 "National Defense Report," Ministry of National Defense, Republic of China, 2019, 44.

111 Ibid., 68.

112 David Axe, "How Good Is Taiwan's New Hypersonic Missile?" *National Interest*, December 2, 2019, *https://nationalinterest.org/blog/buzz/how-good-taiwans-new-hypersonic-missile-101402*; "Yun Feng," Missile Threat Project, Center for Strategic and International Studies, last updated June 15, 2018, *https://missilethreat.csis.org/missile/yun-feng/*.

113 "Yun Feng," Center for Strategic and International Studies.

114 Speier, et al., "Hypersonic Missile Nonproliferation," 93.

115 Ibid., 92.

become clear in time, current development programs and military capabilities ensure that the three great powers in the region will, within a few years, have a strike capability that is virtually impossible to detect and track, against which there are limited possibilities to interdict. Over time, the detection, tracking, and interdiction capabilities may change. But, for approximately 5–10 years, there will be a window wherein the threat of non-nuclear precision strike is a reality for all nations in the region. Perhaps the most substantial unknown is the ways in which nations' strategic decision-making will be impacted. Will it change force posture, and/or force structure? Will it broaden an arms race across the region? Will it impact approaches to alliances and international relationships, particularly those involving US forces?

Both Russia and China envisage their respective near-operational hypersonic capabilities as additional deterrents, while simultaneously boosting their A2/AD standoff capabilities. While an opportunistic surprise attack or escalation cannot be ruled out for either nation under certain circumstances, the primary objective is to expand freedom of maneuver for their other military capabilities. By increasing the risks of conventional conflict for their US adversary, thereby keeping the threshold for war high, they create greater space for their "gray zone," hybrid, and irregular activities. Thus, the main threat for Indo-Pacific nations in the near term is less from hypersonic weapons directly—which will likely remain a small and exquisite arsenal—but more so from irregular and low-level military capabilities employed with near impunity throughout the region, supported by the threat of hypersonic missiles at higher tiers of the escalation ladder.

The near-term projection of Chinese hypersonic-strike capabilities is limited in range to targets in Southeast Asia and immediate East Asia: a 1,500-mile-range missile from Southern China can cover all of Southeast Asia except the southern half of the Indonesian archipelago, including Jakarta, and from eastern China to western Japan, but likely not Tokyo. Therefore, all nations within that range need to accept they could face a near-instantaneous strike with little to no warning at any time if they attempt to confront or resist Russian or Chinese aggression or coercion. This will remain a reality until the United States or regional nations are sufficiently able to develop counterbalancing capabilities, including in suborbital detection and tracking, interdiction, and counterstrike.

Several regional countries have made the decision to attempt to influence this balance of power in some way. While it will likely take most of that 5–10-year window to realize the capability, Japan's ability to retaliate in kind and respond to military aggression within its area of interest may provide a counterbalance to Russia and China around their contested sovereign region. While Australia does not have a stated plan to attain hypersonic capabilities, it is postured to do so quickly and in collaboration with the United States if it so chooses, in accordance with its current emphasis on long-range strike capabilities.

Parts of India will be vulnerable to strike from western China, but there are fewer units currently postured in that region, and longer-term warnings will likely be evident of a new threat. Moreover, much of India's missile-defense forces are already located in the north (though mostly toward the northwest), and as a nuclear power itself, India retains a significant deterrent capability beyond those of other regional nations. It also has the most advanced rocket and space programs of the nations discussed here, even if they are not yet focused on hypersonic capabilities.

For South Korea, Taiwan, and Singapore—all of which are within range of China's near-term operational capabilities—there has been no indication of an intent to develop hypersonic capabilities, and only minimal discussion of preparing to counter them.

Missile-defense capabilities across the region are uneven. THAAD capabilities are currently deployed in South Korea and Guam. Patriots are located in South Korea and Japan. And Aegis capabilities of varying levels of sophistication and quantity are employed by Australia, Japan, South Korea, and deployed US ships. There are a variety of early-detection systems in Hawaii, Australia, Japan, and elsewhere.[116]

116 Kingston Reif, "US Allied and Ballistic Missile Defenses in the Asia-Pacific," *Arms Control Association*, January 2019, *https://www.armscontrol.org/factsheets/us-allied-ballistic-missile-defenses-asia-pacific-region*.

CONCLUSION

The ultimate impact and potential military advantage provided by hypersonic weapons are not yet clear. Regardless of whether they are truly "unstoppable" or just an additional strike vector for the major regional powers, they will change the asymmetries of power across the Indo-Pacific, and will likely alter current strategic assumptions and political risk analyses. The ways in which political decisions and risk assessments are made requires further research, including extensive wargaming of various plausible conflict scenarios, to better understand how those dynamics might evolve.

Hypersonic weapons are seen by all three of the great powers as vital capabilities, and these capabilities will remain critical elements of their increasing competition and rivalry. While middle powers in the region will always face military overmatch in certain capabilities, the implications for this emerging one need to be better understood and new ways to counterbalance or mitigate it developed, or the potential *fait accompli* defeat will become accepted. Due to the unique characteristics of this capability, regional cooperation and understanding are more vital than ever if regional security and strategic stability are to be maintained.

About the Authors

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He has previously been a partner at One Defense, a next-generation defense consulting firm assisting technology start-ups, and a senior consultant at Noetic, a boutique strategic consulting firm. In these roles he has facilitated enhanced corporate innovation, business growth of technology start-ups as well as assisting international, military, federal, and local government agencies on a range of issues. Through this work, Watts evaluated the viability of cutting edge technologies and supported their growth; improved strategic planning and technology evaluation approaches; exercised emergency management teams; facilitated non-traditional interagency initiatives; developed new operating concepts; and analyzed the impact and opportunities of emerging, disruptive technologies and threats.

Prior to moving to the United States, Watts was a staff officer at the Australian Department of Defence, working in a variety of strategic planning, implementation, evaluation, and management roles. His primary focus was organizational capacity building, the development and implementation of strategic guidance, and military preparedness. Watts also spent more than a dozen years in the Australian Army Reserves, where he held command, training, officer development, and emergency management positions. His most recent position was as a liaison officer with the Virginia National Guard.

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Massa contributes to *F*D research on nuclear security and arms control, the Future of DHS Project, the Commanders Series, and other endeavors. Having supported the launch of *Forward* Defense as the Scowcroft Center's newest practice area, he continues to carry out program administration in strategy, budgeting, business development, and event planning. He is a second-year master's student in the Security Studies Program at the Georgetown University School of Foreign Service. His research focuses on nuclear weapons, emerging technology, and the Arctic.

Massa graduated *magna cum laude* from Georgetown University with a degree in Science, Technology, and International Affairs. He was awarded honors in his major for a senior thesis on a theory of nuclear ballistic missile submarine strategy. He was elected to several honors societies, including *Phi Beta Kappa* (national), *Pi Sigma Alpha* (political science), and *Pi Delta Phi* (French).

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