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Issue Brief

India's Hypersonic Pursuit: Navigating Strategic Stability and the New Global Arms Race

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Introduction

Hypersonic weapons are a major focus of modern military technology developments over the past decade, sculpting the future of global strategic stability and defence capabilities. Hypersonic weapons, travelling at speeds exceeding Mach 5 while retaining excellent manoeuvrability, present both an opportunity and a challenge for nations across the globe. With global powers such as the US, Russia, and China, along with emerging players like India, vying for hypersonic technology, the global security paradigm faces potential disruptions. The predominant theme of this Issue Brief is on the technological dimensions, strategic significance, and geo-political implications of hypersonic weapons development. It examines how these modern weapons impact deterrence stability (and potential instability) as well as crisis management and the nature of warfare. In examining the complications of these modern weapons, this Issue Brief seeks to present a thorough understanding of hypersonic weapons.

What are Hypersonic Weapons?

Hypersonic missiles are a type of weapon that travels faster than Mach 5, or five times the speed of sound (330m/s) (Tripathi, 2024). Although speed is the most striking feature of hypersonic weapons, what makes them stand out is the ability to manoeuvre during flight, making these missiles capable of steering their direction and avoiding detection and interception. This combination of high speed and manoeuvrability makes hypersonic weapons unique as well as challenging to defend against.

The three main types of hypersonic missiles are characterised as follows (Boyd, 2023):

1. Hypersonic Glide Vehicles (HGVs):

Like ballistic missiles, HGVs are launched into the upper atmosphere with rockets. However, they do not travel along a predictable flight path; instead, they separate from their rocket and glide to hypersonic speeds towards targets on Earth. HGVs are highly unpredictable throughout their flight path because they can manoeuvre. They generally have a long range, possibly even equivalent to intercontinental ballistic missiles (ICBMs).

2. Hypersonic Cruise Missiles:

These missiles use scramjet engines, which can help maintain hypersonic speeds throughout their flight. These air-breathing engines are suitable for hypersonic speeds and are called scramjets[1].

Whereas HGVs glide at the edge of space, hypersonic cruise missiles fly about 200 feet off the deck (Tripathi, 2024). They are fast and highly manoeuvrable; a deadly weapon.

3. Aero-ballistic Missiles:

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[1] Scramjet Technology is identified as one of the fundamentals of a hypersonic weapon. Unlike standard subsonic or ramjet engines, a scramjet uses an inlet force in supersonic compressed air before mixing it with hydrogen fuel, thus allowing the engine to achieve Mach 5 speeds and beyond.

This is dropped from an aircraft, using a rocket to accelerate it up to hypersonic speeds, and then follows on a ballistic flight path. Aero-ballistic missiles like Russia's Kinzhal are highly challenging for current defences. Although both hypersonic and ballistic missiles may travel at significant speeds, they differ significantly in important ways that affect their performance and strategic consequences.

Their flight routes are one of the biggest differences. Ballistic missiles travel in a dependable parabolic pattern, arcing high into space and then falling towards their destination. They are more susceptible to being discovered and intercepted because of their predictable route. On the other hand, hypersonic missiles—that is, cruise missiles and hypersonic glide vehicles—can manoeuvre during flight. Because of their ability to change direction suddenly, they are very difficult to track and intercept.

The operational altitudes of these missile systems also differ considerably. Intercontinental ballistic missiles spend a substantial portion of their flight trajectory within space. As a result, they have limited manoeuvrability once they reach the terminal phase of their flight. By contrast, hypersonic missiles generally spend their flight time within the upper reaches of the atmosphere. This trajectory allows them to manoeuvre more flexibly, and also aids in their evasion capabilities.

There is another distinct difference between these missile systems: their ability to manoeuvre. Ballistic missiles have limited ability to manoeuvre, particularly during the terminal phase of their flight path. This is characterised as the phase of flight in which the missile is still headed towards the target. Hypersonic missiles, conversely, can manoeuvre continually throughout their flight path, including during the terminal phase. This capability to manoeuvre dramatically increases the chances of a hypersonic missile evading defensive measures and successfully reaching its intended target. The unpredictable flight paths make them incredibly difficult to intercept, undermining traditional defensive strategies.

There are also significant differences in the speed profiles of ICBMs and hypersonic missiles. ICBMs can achieve extremely high speeds of around 15,000 miles per hour (roughly Mach 20) at their peak, often at a particular stage of flight (Seldin, 2022). In contrast, hypersonic missiles have high speeds throughout the entire flight, but may not attain the ultra-high speeds of ICBMs. Furthermore, they are able to manoeuvre at these high speeds, providing a marked advantage over ballistic missiles. Lastly, hypersonic missiles are unique in their particular characteristics, which present novel detection and interception challenges. Since ballistic missiles follow a predictable trajectory, intercepting them is not as difficult—under the right conditions. On the other hand, conventional cruise missiles are slow and can be easily tracked to a target with specialised radar systems, which gives an air defence system time to respond. By comparison, hypersonic weapons fly at high speeds (Mach 5 or more) and operate quickly over short distances that make them hard for traditional radars to detect, let alone engage in any capacity. Their ability to evade makes them prospective 'game-changers' in warfare (Seldin, 2022).

Global Developments in Hypersonic Weapons

Hypersonic weapons have become a key focus of defence investment for major global powers like the United States, Russia, and China. These three countries have prioritised the technology and are investing significant resources into complex systems that reflect their unique geo-strategic concerns and military objectives. Despite the fact that each country sees strategic value for their security in hypersonic weapons capability, they each execute their own unique approach to the system's design, intended purpose, and how it fits into their existing military doctrines.

The United States

The United States' development of hypersonic weapons and its strategic rationale have evolved significantly over time. The US' foundational interest in hypersonics technology was under the Prompt Global Strike (PGS) initiative established in 2003, following discussions with Russia concerning the issue of non-nuclear strategic capabilities (Klare, 2019). Initially, the goal was to develop a capability to strike high-value targets anywhere globally in an exceedingly short period, with an extraordinary degree of accuracy. The PGS initiative was launched to avoid using nuclear weapons, forward-based forces, or regional allies and bases (Klare, 2019).

Once PGS started, the focus on hypersonics shifted to the development of conventionally armed, intermediate-range systems for use in regional conflicts, especially focusing on regional adversaries. The primary reason for developing hypersonic capabilities then shifted to the ability to rapidly incapacitate an adversary's counterforce capabilities at the onset of hostilities in order to pave a path for traditional follow-on air, sea, and ground forces. This latest regional focus on hypersonics is especially relevant to potential conflict with China in the Asia-Pacific. Since the Obama administration's 'pivot to the Pacific' in 2011, US military planners have been looking for advanced weaponry to counter China's enhanced defensive forces in this region (Klare, 2019).

Additionally, the strategic importance of hypersonic weapons is reinforced in the United States National Defense Strategy released in 2018, as a capability required to preserve and enhance strategic deterrence and global military advantage for the US in the 21st century. Although the US has been working on hypersonic technologies from the early 2000s, these efforts are born out of the need to sustain the Prompt Global Strike (PGS) mission initiative started by the George W. Bush administration.

Currently, the U.S. Department of Defense is managing five substantial hypersonic programmes and two technology demonstrators—none have yet been formally declared operational (Henry and Slaars, 2022).

In the area of hypersonic glide vehicles, the U.S. Army is managing the Long Range Hypersonic Weapon (LRHW) programme, which makes use of a Common Hypersonic Glide Body (C-HGB) in collaboration with the U.S. Navy. The Navy is undertaking the Conventional Prompt Strike (CPS) programme, an evolution of the earlier Prompt Global Strike concept that aims to equip the Zumwalt-class cruisers and the Virginia-class Block V attack submarines with hypersonic glide vehicle capabilities (Henry and Slaars, 2022).

The U.S. Air Force has its own glide vehicle programme. The Air-launched Rapid Response Weapon (ARRW, designated AGM-183A) is committed to be launched from B-52 aircraft and potentially B-1 aircraft. After three failed tests, the Air Force successfully conducted a flight test of the ARRW missile launched from a B-52H on May 14, 2022 (Henry and Slaars, 2022).

In addition to glide vehicles, the US military is developing hypersonic cruise missiles employing ramjet technology[2]. These projects include the Hypersonic Attack Cruise Missile (HACM), as well as the Hypersonic Air-breathing Weapons Concept (HAWC) demonstrator, and the sea-based Hypersonic Air-Launched Offensive (HALO) (Henry and Slaars, 2022). The HALO is specifically outfitted for carrier-based F/A-18 Super Hornet aircraft. The US hopes to have these capabilities operational by 2025. The US has developed its hypersonic weapons primarily for conventional (non-nuclear) payloads, rather than to carry nuclear warheads. Additionally, the US has intentionally incorporated specific designs that differentiate its hypersonic glide vehicles from traditional ballistic missiles. This is meant to avoid potential miscalculations and mitigate the risk of unintended nuclear escalation during crises (Tracy and Wright, 2024).

Russia

Russia has been developing its hypersonic weapons as a kind of strategic counter to the US missile defence—an approach in which Washington and Moscow have a differing array of missiles designed for this tactical strategy. The catalyst for this shift was the US withdrawal from the Anti-Ballistic Missile Treaty in 2002, which led Russian officials to fear that unrestricted deployment of missile defences by Washington would undermine Russia's strategic nuclear deterrence: if a country could defend itself with impunity against incoming missiles, it might be tempted to launch an offensive strike at Russia and neutralise its retaliatory capabilities unharmed (Klare, 2019). Russia has thus been largely focused on developing nuclear-armed, manoeuvrable hypersonic delivery systems to fill this perceived vulnerability (Klare, 2019). The strategy is designed to ensure that Russia has a secure nuclear deterrent and creates new arms that could penetrate prospective US missile defences as well as existing ones. This strategy shows Russia's need both to preserve strategic stability with the United States and obtain an edge in a prospective regional conflict—most particularly, in Europe (Klare, 2019).

One of the prime examples of Russia's new hypersonic strategic weapons is the Avangard system. Deployed on a small number of Russian ICBMs, the Avangard was first fielded in 2019. It is an intercontinental hypersonic glider that is capable of carrying nuclear warheads and manoeuvring at speeds which can exceed Mach 20 or beyond (Henry and Slaars, 2022). Russian President Vladimir Putin underlined the strategic value of these weapons, describing this test flight as, "This is a major event in the life of the armed forces and, perhaps, in the life of the country" (Klare, 2019). The argument itself emphasises how important hypersonic weapons are in the Russian strategic and national security realm (Henry and Slaars, 2022).

The centre of focus for Russia has been hypersonic warheads for its strategic ICBMs; however, it has not ignored the development of dual-use weapons. One of the most high-profile manifestations of this

[2] Ramjet technology is a form of air-breathing jet engine that operates most efficiently at supersonic speeds. Unlike traditional jet engines, ramjets have no moving parts and rely on the forward motion of the aircraft to compress incoming air. As the supersonic air enters the engine, it is slowed to subsonic speeds, increasing its pressure and temperature. After fuel sprayed into the engine has been ignited, combustion is self-sustaining. Ramjets are incapable of producing thrust at zero airspeed, requiring an alternative method to accelerate the vehicle to operational velocity. This technology finds applications in high-speed aircraft and missiles, offering excellent performance at high supersonic speeds but limited efficiency at lower velocities.

new breed of weapon system is hypersonic missiles like Kh-47 Kinzhal, which is claimed to be approaching Mach 10 in its terminal phase and is developed to be launched from MiG-31K interceptors or Tu-22M3 heavy bombers (Henry and Slaars, 2022). With a reported range of 1,200 miles, the Kinzhal was specifically designed for use against NATO forces in Europe and the Atlantic. It is a formidable threat in regional defences because of its ability to surpass the current interceptors. The 3M22 Zircon (Tsirkon), an upcoming Russian hypersonic missile, is the one that is the most heard about in the public domain. It is said that this scramjet-powered missile can hit speeds higher than Mach 8 and enter a range of between 500 to 1,000 km (Henry and Slaars, 2022).

The emergence of hypersonic weapons in Russia has also been given a practical application. However, the Kinzhal was reportedly used in combat for the first time during Russia's invasion of Ukraine between 24 February and April, exploding above ground on several occasions (Balmforth, Dysa, Jones, & Osterman, 2024). Others had never been used operatively, so it was a great litmus test for the employment of hypersonic weapons.

China

China's development of hypersonic weapons is being guided by a strategic imperative largely grounded in regional issues, rather than global challenges: namely, prospective crises closer to home in the Asia-Pacific theatre. Such a posture fits neatly within the broader Chinese military strategy of building anti-access/area denial (A2/AD) capabilities. China is also pursuing hypersonic weapons to offset what it perceives as US military advantages in the region, allowing China to rapidly and decisively neutralise key US assets early on in a conflict, and serve as a deterrent against potential American involvement in regional disputes involving Chinese territorial claims or interests.

This strategic significance for China is apparent in the context of events such as potential conflicts over Taiwan or disputes within the South China Sea. These weapons could completely bypass US missile defence systems and give China a way to more quickly hit high-value targets like aircraft carriers or regional bases. The ability of these weapons to threaten the US homeland might make Washington think twice about intervening in conflicts close to China, further easing pressure on Beijing and expanding its strategic space around Asia.

China's hypersonic weapons programme is extensive, encompassing a wide array of systems ranging from established technologies to the cutting edge of scientific capabilities. In addition to the newer hypersonic weapons, China also possesses older ballistic missiles such as the DF-21 and DF-26, which are equipped with manoeuvring warheads and can achieve hypersonic terminal velocities (Henry and Slaars, 2022).

Once called 'Guam killers' based on their potential to threaten US bases in the region, they are now more commonly referred to as: 'carrier killers' (due to their theoretical anti-ship role). The DF-26 has been openly reported as being able to launch precision conventional or nuclear strikes against ground targets (Henry and Slaars, 2022).

A key component of China's hypersonic armoury is the DF-17, a hypersonic coasting glide vehicle, revealed publicly in October 2019 as part of celebrations commemorating the People's Republic of China on its 70th anniversary. The DF-17 is a medium-range ballistic missile composed of a DF-ZF glider. This system is reported to have a range of 1,700 km and can achieve speeds of Mach 5. The DF-ZF appears to be intended to target US bases, warships, and missile batteries in the region, as part of China's anti-access/area-denial (A2/AD) strategy. As such, this hypersonic weapon fits neatly into China's broader strategic approach.

China reportedly tested an intercontinental hypersonic glider in August 2021, which, according to US Chairman of the Joint Chiefs of Staff General Mike Milley, was a 'Sputnik moment'[3] for American armed forces. (Henry and Slaars, 2022). This would mean that China is looking at deterrence capabilities from a strategic perspective and not just regional use of hypersonic weapons.

India's Development of Hypersonic Weapons

India from the onset has shown much promise in terms of developing hypersonic missile technology, and its advancements over the years reflect India's steady growth towards improving their strategic deterrence capabilities, matching pace with global technological breakthroughs. Indian efforts in the domain broadly fall into two categories—Hypersonic Glide Vehicles (HGVs) and Hypersonic Cruise Missiles (HCMs).

On the Hypersonic Glide Vehicle front, while specifics of the Indian programme are unknown in the public domain, it is understood that this has been a continuous focus area for Defence Research and Development Organisation (DRDO). This advancement likely leverages India's existing missile technology, which can provide suitable boost vehicles for hypersonic gliders. Valuable insights have been gained from the Indian Space Research Organisation's (ISRO) Reusable Launch Vehicle Technology Demonstrator (RLV-TD) test in May 2016. This test, which was flown up to Mach 4.78, provided data on aerothermodynamic performance assessment under high dynamic pressure as well as hypersonic glide vehicle systems such as autonomous navigation, guidance and control, and Thermal Protection System (TPS) functionality (Alam, 2024).

In Hypersonic Reference Systems, India has made much more progress, already covering major milestones. In September 2020, DRDO flight tested the Hypersonic Technology Demonstrator Vehicle (HSTDV), proving its capability for a hypersonic cruise vehicle powered by an air-breathing scramjet engine. During the test flight, key technologies were demonstrated, including high-performance and

[3] The term "Sputnik moment" describes a point in time, usually associated with some crisis or challenge from an opposing nation when the urgency of striving to advance technologically or scientifically suddenly seems incontrovertible. The term comes from the launch of Sputnik 1 by the erstwhile Soviet Union on October 4, 1957. The event shocked the US, demonstrating that the Soviets had beaten America at its own game in space tech. It sparked the Space Race between America and Russia, leading to massive expansion of US government investments in science research and education as well as increased NASA space exploration. Today, the term "Sputnik moment" is used more generally to mean any single event that spurs a nation or organisation to redouble its efforts in a particular field to avoid falling behind competitors.

controllable combustion technology during hypersonic flight, with a feature of attaining speeds above Mach 6 (2 km/s) for over twenty seconds by the tested vehicle (Nagappa, 2023). With this test, India has taken a giant step forward in the hypersonic world.

Preceding the HSTDV test, ISRO had already established scramjet engine technology with its Advanced Technology Vehicle (ATV) in August 2016. Two scramjet propulsion modules, integrated on the ATV and operating at Mach 6 for a duration of five seconds using hydrogen fuel, were planned in this test. The tests have been significant in pushing the hypersonic capabilities of India, and offer a path for future research (Nagappa, 2023). India, together with Russia, is also developing BrahMos-II, a hypersonic missile based on the current cruise missile. Using a scramjet engine, the missile will reach speeds of more than Mach 7 and it should become operational no earlier than in 2025 (Mukherjee, 2024). The BrahMos-II project is India’s effort to develop a high hypersonic missile.

A major development in India’s hypersonic research infrastructure came in February 2024, where the Indian Institute of Technology Kanpur (IIT-K) successfully laid out and demonstrated the first Hypervelocity Expansion Tunnel Test Facility, denoted as S2. The 24-metre-long ‘S2’ facility, installed in IIT Kanpur’s Hypersonic Experimental Aerodynamics Laboratory (HEAL), is capable of providing flight velocities ranging from 3 to about 10 km/s. The S2 hypersonic wind tunnel, nicknamed ‘Jigarthanda’, can simulate conditions equivalent to a journey through Earth’s atmosphere at Mach numbers higher than unity. This opens up many avenues for global-level research and development programmes, including atmospheric re-entry of vehicle stage separation, asteroid entry studies, scramjet testing configuration validation, and ballistic missile threat signature examination, among others (Chopra, 2024). The successful demonstration is a major step towards India having the capacity to carry out indigenous advanced-level hypersonic studies.

India has also made progress in related missile technologies that, while not strictly hypersonic, are still part of the same unprecedented category of high-speed weaponry. It was in October 2020 that India test-fired the Mach 7.5-capable Shaurya missile, with a range of up to 750 km. In December 2021, India successfully tested the Agni-P missile, showing off its Multiple Independent Reentry Vehicle (MIRV) technology at a higher scale than seen so far to be applied to hypersonics (Bommakanti and Pant, 2022). This growing emphasis on indigenisation in the country is reflected prominently in a 2023 statement by BrahMos Aerospace Corporation that they could design and develop a hypersonic missile within eight years from the date of government approval (Sinha, 2023). The statement suggests that India is becoming more self-assured about its own hypersonic technology research and development. Despite that, successful tests, the ongoing efforts of even more advanced systems, and infrastructure development such as the S2 facility in IIT–Kanpur suggest India is well on its way to acquiring a strategic capability in this critical branch of defence technology.

What is Strategic Stability and how is it related to Hypersonic Weapons?

Strategic stability is a condition of balance in international relations which inhibits nations from engaging in war, based on the view that risk and costs outweigh potential gains. Traditionally, in the context of nuclear-armed states, it implies that no state will attack another, because retaliation would be catastrophic.

Hypersonic weapons have a complex relationship with strategic stability—bolstering it in some ways, weakening it in others. In destabilising ways, due to their high speed and manoeuvrability, hypersonic weapons can shorten warning times for potential attacks, compressing decision-making time, thereby running the risk of misperception or accidental escalation in a crisis. Some nations may be emboldened by the fact that they can bypass traditional missile defence systems, leading them to adopt more hostile stances or possibly consider a preemptive strike. Additionally, ambiguity surrounding the payload (conventional or nuclear) of a hypersonic weapon could be misunderstood as signals about each side's strategic objectives during a conflict, further complicating crisis management.

On the other hand, hypersonic weapons could potentially have a stabilising effect by enhancing deterrence. Their improved credibility and flexibility in response options may reduce the likelihood of conflict. In theory, the precision of these weapons could enable more targeted strikes with a lower risk of collateral damage. However, the practical implications of this claim remain subject to change.

The three dimensions of strategic stability in relation to global developments in hypersonic weapons are deterrence stability, crisis stability, and arms race stability (Abbasi, 2023).

Deterrence Stability

We must take into account the condition of deterrence stability, which is a balance in which it is not advisable for any adversary to initiate conflict. Hypersonic weapons could upset this balance; they would represent new, hard-to-counter offensive capabilities. Hypersonic weapons deployed by the US, Russia, and China have raised global concerns about potential changes in strategic balance and the risk of miscalculation.

Specifically, the successful trials of the Hypersonic Glide Vehicle by India signify a dramatic change in deterrence dynamics regarding Indian hypersonic weapon development. This technological leapfrog capability presents India with a potential first-strike ability, which has the propensity to blur Pakistan's nuclear deterrence calculus. Strategic stability between India and Pakistan is especially fragile because of their geographical proximity. The speeds of hypersonic weapons make possible flight times of just a couple of minutes compared to conventional missiles, which cover those ranges in 5-10 minutes. Such compression of time places serious constraints on early warning and decision-making processes (Abbasi, 2023).

Further, Pakistan currently has no viable means of defending against hypersonic weapons, which in turn reinforces an Indian strategic advantage. That technological prowess could give India additional confidence to follow a more aggressive approach against Pakistan, which again would only further destabilise the region. There is also some worry over a potential Indian false confidence in launching a hypersonic 'first strike' and being able to absorb any retaliatory Pakistan missile attack. This situation has the potential to dangerously undermine the existing system of deterrence (Abbasi, 2023).

Most dangerous of all is the dual-use capacity and technologies for hypersonic weapons to carry both conventional and nuclear warheads, thereby inherently undermining strategic stability. Moreover, even if a hypersonic weapon is carrying a conventional payload, the extreme speed at which it operates—in some cases Mach 20 or greater—would make it extremely difficult to distinguish them from those with nuclear warheads (Abbasi, 2023). Such confusion, in turn, could lead to misinterpretation of intentions and lower the threshold for nuclear conflict, as decision-makers may feel compelled to respond with nuclear force in the face of ambiguous threats.

The regional context compounds the deterrence issues that India faces. China's hypersonic technology is so rapidly advanced that it has the potential to create a massive capability asymmetry between these two nuclear-armed neighbours. The bottom line, however, is that this imbalance will likely invite China to increase its aggressive posture and hold out with a policy of coercive diplomacy over other claimants in the neighbourhood, which could further erode India's deterrence. Additionally, the deployment of hypersonic weapons profoundly strains both warning infrastructure and decision-making processes. These compressed times for identification and response to potential threats only increase the risk of misunderstandings, miscalculations, or inadvertent escalation. It is perhaps most acute for India, which has to cope with a multiplicity of nuclear-armed states in its neighbourhood and dynamic forces operating at regional levels.

This development is going to be a problem for India's nuclear deterrence doctrine due to the rise of hypersonic weapons.

These weapons have forced policymakers to re-examine their assumptions regarding long-held deterrence doctrines by compressing reaction times, eroding second-strike capabilities, creating strategic ambiguity, and accentuating regional imbalances (Abbasi, 2023). As this technology matures further, India will have to shape its strategy options and capabilities in order to sustain a credible nuclear deterrence posture under these changed circumstances.

Crisis Stability

Given that hypersonic weapons cut decision time to mere minutes, this could initiate a 'use-or-lose' logic, where it may even be desirable for a state with these capabilities not only to strike first but also to do so as soon as possible (Abbasi, 2023). These dual-capable systems (capable of carrying both conventional and nuclear warheads) add to the complexity as well as the risk of misinterpretation in any crises. India's hypersonic weapons will add a new dimension to crisis stability challenges within the region. The big issue with nuclear weapons is that these are dual-capable weapons—it is difficult to differentiate whether a missile making an approach has conventional warheads or nukes. This means that in an armed conflict situation, a mix-up between regular and nuclear-armed hypersonic missiles might spark accidental escalation.

The ambiguity surrounding the nature of an incoming hypersonic weapon could lead the target country to respond with nuclear weapons out of an abundance of caution. Hypersonic weapon speeds and manoeuvrability also shorten decision times to near zero in a crisis. This compression of time carries with it a sense that there will be less room to manoeuvre, raising the spectre of getting calculations wrong and either misjudging or making hasty decisions in ways that are more likely to trigger confrontation. This is where the idea of 'conventional-nuclear entanglement' becomes particularly relevant[4]. India could opt to use hypersonic missiles, defeating an adversary's nuclear capability or as a counterforce tool (Abbasi, 2023). Nevertheless, the adversary might misinterpret this as a nuclear first strike, leading to possible displays of retaliation.

Arms Race Stability

The development of hypersonic weapons by major powers has triggered a second arms race among many states to pursue offensive hypersonic capabilities and potentially viable countermeasures. The advent of hypersonic weapons has generated a traditional arms race among major military powers, the US and China, long with Russia. Each nation initially pursued these weapons for unique strategic purposes, but their efforts have recently accelerated in response to perceived progress by rivals.

This is the essence of what international relations theorists refer to as a 'security dilemma'[5], where efforts by one state to increase its security can lead other states to respond, ultimately resulting in decreased security for all parties; an anarchic world.

The arms race in hypersonic weapons can be subject to 'Game Theory', using a famous concept given by mathematician John Nash and called the Prisoner's Dilemma. In this scenario, each country faces a choice: whether to go along and develop hypersonic weapons, or not. The optimal outcome for global security would be if all nations chose not to pursue these weapons. However, the fear that others might gain a strategic advantage creates a strong incentive for each country to develop its own hypersonic capabilities, even though this leads to a suboptimal outcome for all involved.

The Pentagon's acting defence secretary noted US concerns that China and Russia have moved ahead on hypersonic weapons capabilities. Former Commander of the U.S. Indo-Pacific Command Admiral Harry Harris asked Congress to increase its spending on such weapons systems, noting that China's development outpaces that of the US, and Under Secretary of Defense for Research and Engineering Michael Griffin stressed the need for increasing funding in order to stay ahead technologically (Klare, 2019). "The United States is not yet doing all that we need to do to respond to hypersonic missile threats…I did not take this job to reach parity with adversaries. I want to make them worry about catching

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[4] The term "conventional-nuclear entanglement" is not associated with a single author or theorist. Although he did not coin the term, James Acton, a physicist and co-director of the Nuclear Policy Program at the Carnegie Endowment for International Peace, has been instrumental in popularising and developing the concept. He has written extensively on the subject, including a significant 2018 report titled "Escalation through Entanglement: How the Vulnerability of Command-and-Control Systems Raises the Risks of an Inadvertent Nuclear War."

[5]Security dilemma is a concept in international relations which describes a situation wherein actions undertaken by one country to enhance its own security can lead to heightened insecurity for other countries. This action perhaps can prompt the other countries to respond with similar measures, resulting in a cycle of tensions and conflicts, even when none of the involved actors desire it. John Herz, who coined the term in 1951, emphasised how the anarchic nature of the international system compels states to seek more power for self-protection, inadvertently threatening others. Similarly, Herbert Butterfield described it as the "absolute predicament" of international politics, highlighting the tragic nature of states' inability to fully reassure one another of their peaceful intentions.

up with us again." (Dickstein, 2018). This rhetoric conveys the vying and aggressive ethos of an arms race and what is perceived (both in Cold War culture, as well as today) as a need to stay ahead.

That said, the accelerated pursuit of hypersonic weapons development presents significant challenges as well as concerns in terms of escalatory pressures and strategic stability. The weapons are not only primarily designed for offensive use but also—at least in a regional context—to destroy high-value enemy assets early in the conflict. This capability makes it even more dangerous, as minor crises could quickly escalate into major wars if leaders are tempted to pre-emptively use the weapons to gain a strategic advantage.

Finally, the possible use of hypersonic weapons will also raise 'warhead ambiguity' and 'target ambiguity' issues (Klare, 2019). The trouble is, 'warhead ambiguity'—i.e., not knowing if the hypersonic weapon aimed at a territory has a conventional or nuclear warhead and thus might require an even more excessive response—is a matter to be discussed.

'Target ambiguity' results from the uncertainty of hypersonic attacks and how they could threaten conventional as well as nuclear command-and-control facilities, a situation that would lead to an erroneous and deadly progression into nuclear conflict.

Some analysts say that India's pursuit of hypersonic weapons can spark a new arms race in the South Asian region (Abbasi, 2023). Pakistan, faced with a conventionally superior adversary possessing advanced hypersonic capabilities, may feel compelled to pursue similar technologies or invest in asymmetric capabilities to maintain strategic balance. In this dangerous dynamic, one can imagine a cycle of action and reaction that could further destabilise the region. The strategic environment could become even more muddled, with the arms race extending not just to hypersonic weapons but also to advanced missile defence systems. The programme has implications for India's competition with China in hypersonic weapons as well. India could see these weapons as some deterrence vis-à-vis a conventionally superior China, thereby possibly changing the overall strategic scenario in Asia.

The veil of secrecy over India's hypersonic programme is creating threat perceptions in neighbouring countries, especially Pakistan. Such lack of transparency might ultimately fuel arms race and instability in the region. These cutting-edge weapons systems also pose potential questions about whether India could be trusted to safely handle them. The recent BrahMos misfiring incident illustrated the risk of accidents or miscalculations that could provoke inadvertent escalation (Das, Peshimam, & Shahzad, 2022).

Are Hypersonic Weapons hyped up?

There are significant challenges to the hypersonic weapons; a closer examination of the physics behind these missiles and the challenges they face reveals a more nuanced picture that tempers some of the hype surrounding them.

Speed and Manoeuvrability

The biggest advantage of hypersonic missiles is their tremendous speed, which theoretically allows them to reach targets much faster than traditional missiles. However, because these missiles are travelling through the atmosphere at such high speeds, they encounter extreme drag forces that increase proportionally to the square or double of their speed (Tracy & Wright, 2021). This means that a missile flying at Mach 5 experiences 25 times more drag than one at Mach 1, and at Mach 20, the drag increases to 400 times that of Mach 1 (Tracy & Wright, 2021). The missiles slow down due to this, leading to rapid energy loss.

The high speeds of these weapons also present manoeuvrability challenges. Hypersonic missiles are hypothetically able to adjust their course in mid-air, which is often referred to as a major advantage. However, the forces required by them to make significant course corrections at such high velocities are very high. For example, a 30-degree turn for a missile travelling at Mach 15 would require generating a horizontal velocity of Mach 7.5, which would considerably compromise a missile's speed and range. (Tracy and Wright, 2021). This suggests that the vaunted manoeuvrability of hypersonic missiles in reality might not be as robust and independent as is often conceived.

Thermal Management

Advanced thermal management could perhaps be the most daunting challenge for the technicians developing hypersonic weapons. The extreme friction involved in flying so quickly through the air at high altitudes results in heavy heat generation on the surface of the missile. The leading edges of hypersonic aircraft flying at speeds faster than about Mach 10 or above can reach temperatures exceeding 2,000 Kelvin for sustained periods (Tracy & Wright, 2021). This heating raises not only the issue of missile integrity but also significant challenges for onboard electronics and guidance.

The heating problem is particularly pernicious for HGVs, which spend much more time in the atmosphere than do conventional ballistic missiles. Ballistic missiles undergo extreme heating only during a short re-entry period, but HGVs endure intense heating throughout their glide phase, for up to 30 minutes if it is a long-range system. The prolonged exposure to such high heat has created failures in advanced systems testing—like the U.S. Hypersonic Technology Vehicle 2 HTV-2, which attempted to reach Mach 20, in 2011 (Tracy & Wright, 2024).

Detection and Interception

Hypersonic missiles are not inherently stealthy, as claimed by some. The bright exhaust plumes of their rocket boosters can be tracked by current early-warning satellites as they launch. The high temperatures generated during hypersonic flight also cause the missile to have a very visible infrared signature, detectable by space-based sensors that can continuously monitor the trajectory of every single inbound weapon (Tracy & Wright, 2021). Though hypersonic missiles are indeed hard to shoot down—especially by mid-course defence systems that were purpose-designed to be operated outside the atmosphere—they can still be intercepted.

Cost and Practicality

Hypersonic weapons are an extremely expensive process to develop. The United States, for its part, has spent over $10 billion on hypersonic weapons research and development—a figure likely to grow once these weapons enter full-scale production (Tracy & Wright, 2024). However, there is a question of cost efficiency, given this significant investment when weighed against an alternative system, such as Maneuverable Reentry Vehicles (MaRVs) mounted on ballistic missiles, which may provide similar capabilities at lower costs and with fewer technical challenges.

Way Forward

Countries are obliged to clearly describe what existing strategic or tactical gaps hypersonic weapons intend to fill. Are hypersonic weapons truly valuable in military and defence, or are they being developed primarily because technology exists and seems extraordinary? In the absence of a distinct and precise goal, it is difficult to justify spending resources on building such powerful and potentially destabilising weapons.

At the international level, it is imperative that great powers around the world commence dialogue about hypersonic weapons. This should be accompanied by a restart of strategic stability talks and the endorsement of the UN Office for Disarmament Affairs' call for negotiations over a hypersonic weapons protocol. These talks are crucial as none of the treaties existing worldwide thus far talk about hypersonic weapons, and the dangerous arms race which has started among states continues to advance. Such protocols would address the compressed decision-making time these weapons create for military and political leaders, thus reducing the risk of inadvertent conflict.

Arms control measures are critical to manage the risks of hypersonic weapons. That could entail suggesting a global prohibition on flight tests and limits on the number that can be fielded, as well as pondering whether to make hypersonic weapons part of subsequent arms control accords. Taken together, these efforts could begin to put the brakes on a hypersonic arms race and support strategic stability. Also, policymakers and military planners need to undertake carefully calibrated cost-benefit analyses of hypersonic weapons systems—which could run into enormous development costs against their limited, and perhaps zero, actual military utility—before embarking on a frenetic flight towards narrow perceived short-term offensive gains that could destabilise regional or even global strategic stability for long years.

Strategic stability becomes even more crucial in the age of hypersonic weapons. This would involve adopting measures to ease the 'use it or lose it' pressures these weapons create and regarding MAD (Mutual Assured Destruction) as a concept that is in need of re-examination (Abbasi, 2023). The challenge that hypersonics pose to the survivability of second-strike forces also might exacerbate a first-use mindset, as states rush into crisis situations, in part over fears that their strategic deterrents would be neutralised before use. Improving transparency, targeted research and development, crisis management procedures, and testing adequately cover all angles of a robust policy towards hypersonic weapons.

Especially for India, the way forward lies in striking a delicate balance between developing its own hypersonic capabilities and promoting responsible international norms. India is a regional power and thus needs to be part of this geopolitically crucial club militarily in order for it to maintain strategic parity with others regionally as well as globally, safeguarding its own national interests. However, India should also begin international protocols via the ‘big three’ (US, Russia, and China) to foster correct procedures for the development of hypersonic weapons. New Delhi needs to keep up its hypersonic research and development, where it has tested the Hypersonic Technology Demonstrator Vehicle (HSTDV) at six times the speed of sound off the Odisha coast (Press Information Bureau, 2020).

Apart from boosting India’s defensive capabilities, the move would present it with a substantive say in global deliberations on hypersonic weapons.

At the same time, India should not back away from joining and even starting regional as well as global discussions on the implications of the long reach of hypersonic weapons in the build-up to nuclear South Asia. India needs to gear up with strengthened early-warning capabilities and countermeasures against hypersonic threats as well. Such a defensive strategy, combined with the growth of offensive capabilities, will endow India with important elements for achieving a better balanced deterrence posture in the region. India, therefore, should be more open regarding its hypersonic programme and also consult with other nations. Such measures may include, but are not limited to, sharing non-classified data related to test flights, cooperating with international scientific initiatives in the peaceful use of hypersonic technologies, as well as supporting the development of universally accepted norms regarding responsible conduct of hypersonics-enabled assets.

Hypersonic weapons represent a major shift in the development of military technology and global strategic balance. While these next-generation systems will have potential military benefits, they nonetheless also present substantial risks to global stability and security. The competitive nature of the hypersonic arms race, encouraged by great powers and regional states rising on their way to prominence, highlights an imperative for international conversation about nuclear disarmament, and strategic stability talks. Given the sheer size of government investment in these technologies around the world, it is becoming increasingly important for policymakers and military planners to look at how hypersonic weapons would actually stack up against their enormous costs and probable destabilising effects. In the end, efforts to develop hypersonic technologies must not only proceed with caution but also maintain global strategic stability and avoid providing further incentives for aggressive escalation in conflicts. As we go forward, it should be mandatory for nations to handle the creation, development, and probable deployment of hypersonic weapons with due caution, foresight, as well as a united commitment towards international peace and security.

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