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Hypersonic Vehicles and Their Impact on Military Operations and Strategic Stability

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Hypersonic—flight at five times the speed of sound (3,600 mph and above)—promises to revolutionize military affairs in the same fashion that stealth did a generation ago, and the turbojet engine did a generation before[1].

Introduction

Technological innovations have been the primary element in the defence preparedness of some of the P5 nations, predominantly the U.S., Russia, and China. Whether, it is ballistic missile defense; hypersonic glide vehicles; anti-space weapons; or the threat due to a nation's cyber-attack capabilities, there is a constant tussle to develop niche technologies and eventually to have independence in their technological designs so that superiority in the defence domain could be achieved. Unfortunately, this advantage by some nations ultimately impacts the delicate balance of deterrence, resulting in an illogical arms race. One such technology is 'Hypersonic Technology', though piloted and inhabited aircraft making routine use of hypersonic are still years away, all evidence shows that hypersonic weapons capable of launch from aircraft, surface vehicles, ships, and submarines are now within a decade of operational fielding.[2] The fact that this technology has a commercial angle to it makes controlling this technology that much more difficult. This paper aims to analyse the impact of 'Hypersonic Technologies' in the field of defence. Historically, the originator of this technology may be the US but it has been subsequently espoused by other countries, especially the Russians, the Chinese, and soon it will have an impact on other countries particularly India.

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An important principal of war is speed, as this is the essence of flexibility. The faster you can detect and engage the quicker you destroy the enemy. Over the years 'Fire Power and Manoeuvre' have played an essential part in warfare. Both rely on speed and with the advent of Air Power and Aerospace power, manoeuvre and firepower have become more important. President George Bush, post 9/11 attacks, felt that there existed a gap in United States ability to engage quickly, conventionally, any target on the globe effectively. Since then, the Americans have made it a top priority to find solutions to this problem.[3] The answer seems to be what they call the 'Conventional Prompt Global Strike' (CPGS) weapons whereby they would be able to hit a global target in a time frame of as short as one hour.

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Hypersonic Phenomenon

Hypersonic Glide Vehicles (HGV) and Hypersonic Cruise Missiles (HCMs) are the emerging hypersonic weapons which nations desire to master. A HCM (a missile that flies at speeds greater than 5 times the speed of sound) possesses a unique combination of speed, lethality, survivability, and range; also it presents the tactical war fighter with unprecedented capability to respond to long-range threats such as time-critical, hardened, buried, and heavily defended targets.[4] Hypersonic speed is normally related to speed of Mach 5 and above. It is the speed where the aerodynamic heating considerations become as significant as the aerodynamic and structural limits. Scientists first raised the possibility of reaching these speeds in the 1920-1930. At these speeds, air temperature changes the dynamics of flight. At hypersonic speeds above Mach 10, air molecules break apart creating an electrically charged plasma layer around the air vehicle. This phenomenon changes the magnitude of forces generated by air on the aircraft[5]. Hypersonic speed is achievable through rocket propulsion or with air breathing ram jet and scramjet, accelerating the air vehicle once it has achieved supersonic speed.

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All jet engines function on the principle of intake of air, burning of the same with a combusting material and this air is then compressed and exits through an exit valve. This exit of gases produce thrust which enables forward propulsion at high speed. A ramjet is designed around its inlet. It uses the engine's forward motion to compress air without an axial compressor. Ramjets, unlike jet engines, cannot produce thrust at zero air speed. A ramjet powered vehicle requires an assisted take off like a rocket to accelerate it to a speed where it begins to receive air at a reasonable speed to produce thrust. Ramjets produce speeds of Mach 3 and are used in many missiles and could be used for enhancing ranges of artillery shells.[6]

A scramjet supersonic combusting engine is a variant of ramjet air breathing jet engine in which combustion takes place in supersonic airflow. As in ramjets, a scramjet relies on high air vehicle speeds to forcefully compress the incoming air before combustion, and thereafter the air exits at supersonic speed. In the case of a ramjet the exhaust is at subsonic speed. Scramjets are ideal for hypersonic engines.[7]

As is observed, hypersonic vehicles need to be boosted to supersonic speed to enable hypersonic engines to function. Hypersonic vehicles are capable of extending the range of space craft and missiles by extending the range with hypersonic speed and effecting a change of trajectory of the ballistic missile by manoeuvring its path. The aerodynamic lift provided exponentially increases the range of the Hypersonic Glide Vehicle. So this technology is used in the Prompt Global Strike weapons where there is the need for rapid conventional strike worldwide to engage terrorist targets. Also, for this purpose the vision is to develop a Hypersonic Cruise Vehicle (HCV). This autonomous aircraft would be capable of taking off from a conventional military runway and striking targets at a distance of 9000 nautical miles in less than two hours. The vehicle will be flying at speeds up to Mach 8. It would carry a 12000 pound payload comprising of several unpowered, manoeuvrable hypersonic glide vehicles called common aero vehicles, cruise missiles, small diameter bombs, and ammunition. Each common aero vehicle would carry approximately 1000 pounds in ammunition. The aero vehicle system will be able to fly 3000 nautical miles in approximately 800 seconds and deliver 1000 pound penetrator

ammunition. Speeds attained by aero vehicles would reach speeds of Mach 25. The main issue would be thermal protection to the aero vehicle. Having delivered its payload, the Hypersonic Cruise Vehicle will return to base at a speed of Mach 3 to Mach 4. Almost seven countries are developing hypersonic vehicles. They are the weapons of the immediate future.[8]

Significance

From a conceptual standpoint, it is akin to combining the advantageous characteristics of ballistic missiles and cruise missiles into one optimal strike platform - for example, HGVs can utilize the high-speed and high-impact nature of ballistic missiles, but can manoeuvre at various altitudes like cruise missiles and since HGVs are difficult to detect and difficult to intercept, which – when paired with their precision accuracy (via modern guidance technology) – makes them a potent threat.[9] The greatest benefit also is in the capability of a nation to project power globally. For US these weapons effectively circumvent the challenges of A2/AD threat environments, and can strike time-sensitive targets anywhere in the world, thus meet the challenge of distance, shrinking flight times to targets, and can evade sophisticated air defences, which would intercept weapons such as cruise missiles.[10] The other advantages being they can project striking power at a range without falling victim to increasingly sophisticated defences; they compress the shooter-to-target window, and open new engagement opportunities; they rise to the challenge of addressing numerous types of strikes; and they enhance future joint and combined operations.[11] A country equipped with an HGV arsenal can use its munitions to engage in rapid first-strike engagements against air bases, air defence sites, relevant energy and industrial sites (e.g. naval shipyards and dockyards), etc., thus could conceivably scuttle an enemy's military capabilities in short order.[12]

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U.S. Systems

The need for prompt long-range, or global, strike capabilities has been discussed through defense policy studies since 2001. The 2006 Quadrennial Defense Review (QDR) stated that these weapons would provide the U.S. the ability "to attack fixed, hard and deeply buried, mobile and relocatable targets with improved accuracy anywhere in the world promptly upon the President's order." Similarly the 2010 QDR stated that" enhanced long-range strike capabilities are one means of countering growing threats to forward deployed forces and bases and ensuring U.S. power projection capabilities." The main objective of developing Conventional Prompt Global Strike (CPGS) weapons by the U.S has been to deter and defeat adversaries by allowing the United States to attack high-value targets or "fleeting targets" at the start off, or during a conflict thus bringing these into a new category of "offensive strike" weapons.[13] The 2010 Nuclear Posture Review (NPR), further highlighted that these weapons can be used for regional deterrence purposes, thereby, reassuring their allies of a quick countermeasure for any attack by the adversary, thus helping in creating stable regional security architecture. The US Department of Defense (DOD) has also addressed the prompt global strike mission in specific reports in the Air Force doctrine, where they have noted that "rapid power projection based in the continental United States has become the predominant military strategy".[14] However, the technology is not limited to the Air Force but all the three services are developing hypersonic vehicles.

The United States has three service programs under development: the U.S. Air Force's Conventional Strike Missile (CSM), the Defense Advanced Research Projects Agency's (DARPA) Hypersonic Test Vehicle

no. 2 (HTV-2), and the U.S. Army's Advanced Hypersonic Weapon (AHW).[15] Apart from cruise missiles and bombers, long-range ballistic missiles (ICBMs and SLBMs) are also being used for prompt global strike missions. The army is developing an Advanced Hypersonic Weapon (AHW) which would use a hypersonic glider to deliver a conventional payload. Its test in 2011 was successful where it achieved a range of 2,400 miles, but the test on August 26, 2014 failed. However, more tests need to be conducted and so more funds are required. The navy has been speaking about the conventional Trident modification (CTM) since 2006. They had also studied the possibility of developing and deploying of a submarine-launched intermediate-range ballistic missile (SLIRBM). According to the Defense Science Board Task Force, "this missile might have delivered a 2,000- pound payload over a 1,500-mile range, with an accuracy of less than 5 meters. This would allow the missile to reach its target in less than 15 minutes",[16] but due to lack of funds the progress had been thwarted. However, the navy is trying to develop various technologies which may in future "design a conventional prompt strike option from submarines".[17] U.S. Air Force began the Conventional Strike Missile (CSM) program where —the CSM would employ boost-glide technologies and follow a substantially lower depressed trajectory than existing nuclear-armed ballistic missiles, where, after separation, the payload would travel hypersonically to the target while having the capacity to execute substantial cross-range manoeuvre, but due to lack of funds for substantial testing, this might not be ready until well after the middle of this decade.[18]The second contender is HTV-2 which again due to resource crunch may be slowed down. The US had developed it's X-51A series where its first X-51A test flight occurred in May 2010 and was hailed as a success, as the vehicle flew for more than three minutes and reached Mach 4.88, however the next two in 2011 and 2012 had failed but the US continued with the tests and in 2013 launched the final test in this series, an experimental hypersonic aircraft on its swan song test flight where Air Force's X-51A Wave rider reached a top speed of Mach 5.1 during the test flight, traveling more than 230 nautical miles in just over six minutes before crashing into the Pacific Ocean off the California coast.[19] This was powered by its air-breathing supersonic combustion ramjet (scramjet) engine. US is continuing its research with the scramjet technology and efforts are on to develop hypersonic cruise missiles and the twin concept of 'hypersonic air-breathing concept' and 'tactical boost glide concept'. Recently Cmdr. Patrick Evans, the Pentagon spokesperson stated that "The Navy Strategic Systems Program (SSP), on behalf of the Department of Defense, conducted an Intermediate Range Conventional Prompt Strike Flight Experiment-1 (CPS FE-1) test on Oct. 30, 2017, from Pacific Missile Range Facility, Kauai, Hawaii[20]," He further elaborated that "The test collected data on hypersonic boost-glide technologies and test-range performance for long-range atmospheric flight. This data will be used by the Department of Defense to anchor ground testing, modeling, and simulation of hypersonic flight vehicle performance and is applicable to a range of possible Conventional Prompt Strike (CPS) concepts[21]."Thus, hypersonic weapons in future could effectively indict both an adversary's C4ISR systems as well as high value targets including WMD and anti-satellite weapons.

Russia

The news about Russian hypersonic vehicle became public first in February 2004 when they tested a warhead which in future, will fly at hypersonic speed and will be able to change trajectory both in terms of altitude and direction. The tests date back to 2000 and relates to projects developed by Chelomey Design Bureau (NPOmash). The Hypersonic Project is known as '4202'. The Editor in Chief of the portal Military russia Dmitry Kornev had mentioned that the technical name of the tested aircraft was "aeroballistic hypersonic combat equipment" (AGBO).

The hypersonic vehicle research has been for a long time now and it includes glide technologies which mate a rocket booster with a hypersonic glide vehicle, which may or may not incorporate an air-breathing supersonic-combustion scramjet.[22]

The Yu-71 is possibly the first hypersonic Russian vehicle. It is extremely manoeuvrable and can break through any missile defense system, Military experts' state that Russia has reportedly carried out four tests up to June 2015. Russia is test-launching a new hypersonic attack aircraft that can carry nuclear warheads and penetrate missile defense systems, US media said citing a report by Jane's Information Group. The development of the Yu-71 vehicle took several years, and Russia reportedly conducted a test flight on 26 February 2015, with an SS-19 missile trying to deliver the Yu-71 to space. It is said that the Yu-71, a secret missile program codenamed 'Project 4202', has probable speed of up to 11,200 km per hour (7,000 mph) and is extremely maneuverable, which makes it an incredibly dangerous and a difficult to target weapon. Due to its speed and unpredictable trajectory, Yu-71 can evade any missile defence system. It is presumed that Russia may put into service up to 24 nuclear-capable Yu-71 aircraft between 2020 and 2025. Moreover, by that time Russia may have developed the Sarmat. This is a new ICBM that will carry the new hypersonic device. The report also said that Russia's next generation strategic stealth bomber PAK DA will carry hypersonic cruise missiles.[23]

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Russia has also successfully tested its experimental Yu-74 hypersonic glide vehicle. The Yu-74 was carried by the ICBM RS-18A (NATO codename: SS-19 Stiletto) ballistic missile system. The glider was launched from the Dombarovsky missile base in the Orenburg region and hit a target located at Kura Missile Test Range in northern Kamchatka region in the Russian Far East. In 2016 Moscow apparently tested an even more advanced Yu-74 hypersonic attack aircraft. Evidently these gliders have been designed to be loaded onto the new RS-28 Sarmat (NATO codename: SS-X-30 "Satan 2") state-of-the-art heavy liquid-propelled ICBMs, that can carry up to 24 individual re-entry vehicles. When loaded with the Yu-74 hypersonic gliders, the Sarmat will be capable of hitting any target within a 6,200-mile radius in an hour.[24]

Each Yu-74 glider can be equipped with a nuclear warhead, electronic warfare (EW) applications, or false target simulators. These features ensure penetration of any existing and prospective missile defense system of a potential adversary. By adopting such systems Russia's Strategic Missile Forces will significantly increase their efficiency.[25] Defence analyst Victor Litovkin told Radio Sputnik on 29 October 2016 that the cutting-edge warhead is expected to be fitted onto the upgraded Sarmat ICBM. This was the second test of hypersonic warheads for the Sarmat. The first was carried out several months ago on the Kapustin Yar site. The latest test was conducted using the R-36 Voevoda ICBM.

The Sarmat liquid-fuelled, multiple independently targetable re-entry vehicle (MIRV)-equipped, super-heavy thermonuclear armed ICBM is meant as a replacement for the R-36 family. Technical characteristics of the new hypersonic weapon are classified, but it is reported that there are up to 20 independently targetable warheads. Each of them has its own flight program. They fly like cruise missiles but at hypersonic speeds. The new Russian-made weapon is capable of accelerating to a maximum speed of 15 Mach (7 kilometers per second). It is intended for the most advanced intercontinental ballistic missiles in Russia's arsenal. The warhead was created using solely

Russian-made components, including on-board equipment, electronic components and the guidance system, an unnamed source at the Roscosmos State Corporation told Izvestiya. Litovkin further said that "object 4202" has been in development since the Soviet era, but initial concepts and ideas were not completed before the end of the Cold War. This missile too is being developed by the NPO Machine Building plant. This is not an independent missile, but rather a warhead on-board an intercontinental ballistic missile, which, after separation from the launch vehicle, acts like a hypersonic cruise missile would, manoeuvring freely to determine direction and pitch. Each Sarmat will have three hypersonic combat gliders making it an extremely effective weapon.[26]

On 03 June 2017, Russia declared the first test of a hypersonic missile Zircon. The Russian international news site Sputnik suggested Zircon is likely to be installed on Russia's nuclear powered missile strike ship PyotrVeliky. Analysts stated that the missile can fly at Mach 6 and would be impervious to missile defence systems. It is expected to be inducted into Russia's Strategic Forces in the period 2018-2020.[27] The missile employs scramjet technology. It is a manoeuvring Cruise missile whose path would keep varying. It is being developed by NPO Mashinostroyenia.

China

China has the DF-ZF as the current prototype of HGV. China has conducted seven DF-ZF tests till 2016 and assumed to be using a medium-range ballistic missile (MRBM) transporter erector launcher (TEL) as the delivery method for all of its HGV tests.[28] They also claim that their success rate has been much higher than the Russia's Yu-71 and the USA's X-51A hypersonic missile. The main objective for the Chinese is to counter the American BMD systems, especially its PATRIOT-3 (PAC-3) batteries stationed in countries' of East and South East Asia. The low trajectory of the HGV and its intended mid-flight maneuverability is believed to prevent ballistic missile defense (BMD) systems from locking onto its target.[29] The initial aim is to develop HGVs for a regional contest and DF-21C, DF21D, and other such varied missile system with different ranges for its delivery vehicle is being tested. It is speculated that these glide vehicles would be used to target aircraft carriers and other large ships used for long distance power projection, and for anti-carrier operation as the velocity is reduced considerable which results in better manoeuvrability and this combination gives the terminal sensor more time to search and acquire the target before zeroing in on it.[30] Also the enhanced aerodynamics improves accuracy which is a vital element when attacking a moving target.[31] This will impact in future the BMD system of US, Russia, India and the BMD deployed in other countries. The Chinese closely observe the Americans for any new inventions and hence, like the Americans the main trajectory in future would be to ultimately develop the Scramjet technology so that China may also develop a longer range capability for its HGVs to knockout the American systems. Their 2015 white paper emphasises on the military modernisation especially the long range precession strike weapons. From the doctrinal point of view Central Military Commission, in coordination with the PLARF, are interested in determining how the technological advances in hypersonic boost-glide can be integrated into policy and posture.[32] At the technological level, research is at multiple levels which include the academia, military research centers, and industrial platforms and all of them are interlinked, hence the progress is much faster than other nations. Also the Chinese, due to their economic progress, are able to devote substantial financial support to these

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research projects. Some of the institutions involved in this research are the National University of Defence Technology, the Air Force Engineering University, the China Aerospace Engineering Consultation Centre, the China Aerospace Science and Industry Corporation. The strategists have also stated that China may initially use HGVs as a conventional weapon for non-nuclear target, but later on the trajectory would be towards carrying nuclear payload to hit dual targets. This would have an adverse impact on strategic stability in Asia.

India

The Advanced Technology Vehicle (ATV), a sounding rocket for research purposes with a solid booster carrying advanced scramjet engines, was successfully flight tested from the launch pad of the Satish Dhawan Space Centre also known as Sriharikota Range (SHAR) at Sriharikota on 28 August 2016.[33] The ATV could attain a speed of Mach 6. Indian Space Research Organisation (ISRO) plans to use the scramjet for its Avtar programme. ISRO currently uses rocket launch vehicles like Polar Satellite Launch Vehicle (PSLV) to deliver satellites into orbit. PSLVs can be used only once and are designed to carry both, fuel and oxidizer for launch. Scramjets use ambient air to burn fuel, thus saving the need to carry an oxidizer, thereby increasing the payload of the vehicle. Thus, ISRO's Avtar would be a reusable launch vehicle platform capable of carrying out satellite launches by taking off vertically and landing back on a runway. The space craft would use ramjets and scramjets for thrust. Each of these engines will be used in different stages of flight with ramjets at lower speeds, scramjets at hypersonic speeds and cryogenic engines when it reaches the edge of the atmosphere. [34]

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Currently BrahMos is a supersonic cruise missile with a liquid fuelled ramjet engine. With assistance from Russia, BrahMos is moving ahead with its hypersonic version BrahMos II which will have a scramjet engine. The speed of the missile would be Mach 6 in this version thereby increasing its kinetic kill and security against missile defence systems.[35] It is widely reported that the Zircon engine would possibly be used for BrahMos II. With this, India is well on the path of developing these 'state of the art' vehicles.

Impact on Military Operations

Hypersonic vehicles with their high speed would impact military operations exponentially. In the area of surveillance and reconnaissance, hypersonic drones in combination with satellites launched by hypersonic reusable vehicles would be able to provide near real time information. This information could be analysed and thereafter be targeted by hypersonic missiles. These missiles would be both, conventional and nuclear enabling immediate decimation of a target. The dilemma faced by the United States after 9/11 stands resolved. Further, Hypersonic missiles could penetrate any missile defence system as they cannot be intercepted due to their high speed. The kinetic impact on the target would be much higher as the speed of the missile is extremely high.

An offshoot of weapon development would be strategic lift transport vehicles. These would soon be developed. Airbus is planning to develop a transport aircraft which would cross the Atlantic in two hours. This strategic lift would enable movement of troops and equipment globally in lesser time frame.

India has started developing Avtar and BrahMos II which would put it on the right track to contest developments by adversaries and be able to stand up to any threat from these state of the art weapons. The tempo of warfare is increasing day by day. India must develop Hypersonic Vehicles expeditiously.

Challenges

Two prong challenges can be anticipated with HGVs- the first being technological difficulties and second, with HGVs operationalised there will be problems of arms race. As far as technology is concerned, here again the twin challenge is of firstly developing and learning this complex technology and, the second is of requirement of large finances. There are formidable technical barriers to mastering such hypersonic technologies: thermal management and materials; air vehicle and flight control; propulsion for HCMs; and testing, modelling, and simulation[36], are some of the challenges. As far as thermal management and air vehicle and flight control is concerned, the compact size and higher aerodynamic heating associated with HGVs and HCMs make it more difficult to maintain their structure and internal components below their upper temperature limits, and any shape change from material ablation or erosion from high temperatures and velocities can also change the aerodynamic characteristics of the vehicle.[37] Also, hypersonic would clearly be limited in certain ways—for example only fixed, soft targets would be vulnerable to hypersonic attack and targets in hardened, deeply buried shelters would be much harder to reach[38]. As far as finance is concerned, initially for the R&D a large sum would be required which would subsequently be followed for developing the infrastructure and once HGVs get operationalised, the operational cost would also be enormous since initially most of them would be a single weapon and not reusable.

The twin challenge is of firstly developing and learning this complex technology, and secondly this requires large finances.

Compared to nuclear weapons, precision conventional weapons depend majorly on a range of supporting systems -"This includes, first and foremost, highly accurate and swiftly completed intelligence collection, analysis, and dissemination; rigorous mission planning; precise knowledge of the target's aim points (i.e., its vulnerabilities); post-attack damage assessment capabilities to determine whether or not damage objectives have been achieved and whether or not additional strikes are necessary; and, finally, an agile command and control system to manage these complex, interconnected tasks"[39]. So in order for these weapons to be successful, one requires the ability to plan rapidly, to apply the precision to the intelligence and gather that intelligence in a very rapid manner and such decision-making and its accompanying planning may have to occur within an hour's time frame, places unprecedented demands, on the intelligence community[40] . Many in US believe that even they do not as yet have such a capability so it would be very far fetched to assume that in the present scenario the Chinese or the Russians would have this capability.

Like the dual nature of nuclear energy –where nuclear energy could be used to generate power as well as could be misused to develop nuclear weapons, the hypersonic technology can be used for dual purposes to build civilian transport and cargo aircrafts or militarily it could be used to develop HGVs. There had been an increase in number of ballistic and cruise missiles, and to counter this threat, a number of nations had gone in for Ballistic Missile Defense (BMD) systems, but now HGVs would be able to penetrate these BMDs. Considering that HGVs can attack targets within minutes (as the warning time is very less), also even a limited number of HGVs can neutralise the BMD systems, this technology becomes more attractive and more nations would develop these technologies.

Threat to Strategic Deterrence

It is broadly believed that these HGVs will affect strategic stability. Nuclear weapons have tried to build a deterrence quotient for the weaker nations when it comes to intimidation

by stronger nations and these weapons have maintained the status quo, but this might just change with the introduction of hypersonic technology. Some analyst in China, in the past, had believed that the American CPGS weapons will undermine and erode their nuclear deterrent hence initially they had vehemently opposed this but off late, due to technological advancements they have started developing this technology, and in future they are contemplating to have a dual hypersonic weapon, which has the capability to have conventional as well as nuclear payloads. So the arms race in this domain has already started. One likely problem that these weapons might present in future is that one cannot be absolutely certain whether the incoming weapon is a conventionally-armed or nuclear armed HGV because, as mentioned earlier, both Russia and China are likely to arm their HGVs with nuclear and conventional weapons. Same conundrum is there when it comes to hypersonic cruise missiles. Also due to its maneuverability one can mistake the missile's intended destination too. Since HGVs can change direction mid-course, escape missile defences, travel at very low altitudes and have the ability to credibly target nuclear silos so chances of a nation misinterpreting its intentions are high, for example, the intentions may be to destroy conventional forces but it can be construed as an attack on nations' nuclear forces.

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The use of HGVs would in fact increase the use of nuclear weapons as the adversary not possessing HGVs would firstly try to keep the nuclear weapons on high alert whereby they may adopt a policy of 'launch on warning' because as these weapons are very fast hence the reaction time for the threatened nation is very less. Also they would have a dilemma of 'loose it or use it' which would push the decision to its early use, hence they would have to disperse their arsenals and this in turn will create command and control problems.

Thirdly the nations who do not have HGVs would try to increase the number of nuclear weapons to make it difficult for the aggressor to completely destroy their nuclear arsenal and this eventually would result in making these nations' less transparent about their nuclear policies. Thus all these postures are bound to escalate crisis. Hence it is essential that the countries develop a mechanism to manage these technologies.

As far as arms race is concerned, there is already a multi-pronged arms race on, due to the introduction of BMD, ASAT, ASBM etc. and now HGVs would be further added to this already complex military matrix. Banning these vehicles or testing moratorium is not the solution. The fact is that nations will make decisions about the deployment and testing of hypersonic weapons on the basis of relative power and competition and if the United States successfully develops hypersonic technology, one can be sure that Russia and China will do the same and other countries, such as India, may follow.[41] In fact, some nations would consider a moratorium on testing discriminatory[42], especially nations at the early stages of hypersonic technology development won't wish to place themselves at a disadvantage to countries whose technology is more advanced. The only answer ideally would be to have restraint, but since all the major powers are not in unison on this issue, it is better to deliberate the threats and improve confidence-building measures through a multilateral dialogue to mitigate mutual concerns and develop modalities for mutual transparency.

Conclusion

With their high costs and small payloads, hypersonic missiles would be ill-suited to a sustained military campaign, but could be useful as tip-of-the-spear weapons and armed with conventional warheads and

their own kinetic energy; they could attack ships, radar and communications antennas, command and weapons bunkers, airfields, missile launchers, also they could carry nuclear warheads, and could fly in under the radars that watch for ballistic missiles[43], so they are a cause of global concern. Hypersonic long-range strike capabilities are destabilizing, especially if nuclear and conventional deployments are co-mingled without clear command and control systems for each. Additionally, these systems may affect a country's ability to retaliate with nuclear weapons, potentially undermining established deterrent relationships and introducing instability into regional dynamics.[44]

The solution however does not necessarily mean that these technologies should be banned because these can also be used in the commercial sector, so instead of putting limitations on these technologies other options should be chosen. Just like nuclear genie it is difficult to bottle back this technology. Since some states are retaining the option of mounting nuclear warheads on boost-glide vehicles or hypersonic cruise missiles, because these are highly manoeuvrable systems, it could significantly increase nuclear warheads' ability to penetrate midcourse missile defense, so the stakes in developing hypersonic missiles are therefore high—higher than would surround the development of a new, purely conventional capability[45]. So to completely ban these weapons may not be feasible presently. Also more nations are investing in new technologies and controlling them would be a difficult task primarily due to lack of trust between major nations as is visible in South China Sea, Eastern Europe, etc. Hence more realistic approaches need to be adopted. Unilateral cessations by nations to not develop nuclear HGVs, prevent targeting nuclear assets by hypersonic missiles, more transparency in data sharing regarding hypersonic tests can be few options to begin with.

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