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HYPERSONIC WEAPONS : REALITIES AND CHALLENGES

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All major countries of the world are engaged in developing hypersonic weapons that will fly at much faster than five times the speed of sound (Mach 5). China is generally acknowledged as one of the leaders. They displayed a road-mobile version of the DF-17 launched hypersonic glide vehicle (HGV) at a parade in late 2019.[1] China has reportedly also developed an air-launched HGV that could be carried on H-6N bomber. The United States has been developing hypersonic weapons as a part of its conventional prompt global strike program.[2] Of late, the United States has been developing hypersonic glide vehicles, and hypersonic cruise missiles. As Vice Chairman of the Joint Chiefs of Staff and former Commander of U.S. Strategic Command General John Hyten has stated,[3] these weapons could enable "responsive, long-range, strike options against distant, defended, and/or time-critical threats..." Russian military currently has two hypersonic missiles. These are the Avangard and the Kinzhal.[4] Avangard is a nuclear-capable missile, and can fly at over Mach 20.

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Hypersonic Weapons Operational Peculiarities

Two main types of hypersonic weapons are the hypersonic cruise missiles (HCM) and the HGV. HCM are powered by scramjet, and operate below 100,000 feet. HGVs travel higher. Unlike the ballistic missiles which have a relatively well defined, parabolic trajectory, the hypersonic vehicles are more manoeuvrable. The hypersonic weapons can be launched aboard a ballistic missile, or delivered using a wave-rider. The wave-rider design for hypersonic

platforms greatly improves supersonic lift-to-drag ratio, essentially by harnessing lift from the self-generated shockwave which acts like lift producing surface, and is also called compressive lift. The speed and altitude at which hypersonic vehicles fly makes it very difficult to detect, track, and engage. HGVs and HCM follow less predictable paths and are capable of a high degree of manoeuvrability even at terminal stages near target. This makes attack detection, assessment and engagement difficult. The hypersonic weapons have the added advantage of continues manoeuvrability in terminal stages, thus can achieve a high targeting accuracy. Even, a small object hitting accurately at very high velocity can cause much more destruction than an equivalent of TNT.[6] The low-altitude path helps mask HCMs, making them invisible to early warning radars.

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Chinese Hypersonic Capability

China looks at hypersonic weapons for both for tactical use and as strategic deterrent. Beijing has placed greater emphasis on development of HGVs. China's DF-17, medium-range ballistic missile (MRBM) that can launch an HGV has a range of 1,800-2,500 kilometres. The HGV, designated as DF-ZF (previously WU-14), is reported to possess a range of 1,600-2,400 kilometres.[7] China is also reportedly considering deploying HGVs on DF-21 and DF-26 theatre-range ballistic missiles. China has also tested the "wave-rider" design that uses powered flight after launch and creates shockwaves to sustain its lift.[8] This technology could be used for an advanced anti-ship missile. China basically wants to neutralise American conventional advantage in the Indo-Pacific region. Therefore they are building an arsenal of ballistic and cruise missiles, and the hypersonic vehicles which will be difficult for USA to defend against. China is also working on defensive measures against the U.S. hypersonic weapons. If and when China puts nuclear warheads on HGVs, the deterrence would have to be reworked. China may also develop and deploy nuclear-armed HGVs on China's JL-2 submarine-launched ballistic missiles (SLBM).[9] These are meant mainly to operate in Western Pacific for the moment.

China's ultimate target will be to develop conventionally-armed hypersonic weapons that can reach the United States with ability to target high value targets in the U.S. mainland as part of global reach.[10] Similar deployment of the U.S. hypersonic weapons will impact China. The deterrence and strategic calculus will change significantly when USA, China or others develop active defence capability against hypersonic platforms.

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Russia's Hypersonic Weapons

Russia is pursuing two hypersonic weapons programs, the Avangard, and the Kinzhal (Dagger), a manoeuvring

air-launched ballistic missile.[11] The Avangard is a Russian HGV that is carried as a MIRV payload aboard the Sarmat heavy ICBMs. They have both nuclear and conventional payloads. They completed the initial test program in December 2018,[12] when it hit the planned target at the Kura Missile Test Range. The Russian HGV are claimed to comply with the existing strategic arms reduction treaties, including the New START. In December 2019, the first missile regiment of the Strategic Missile Forces armed with the Avangard HGV became operational.[13] They are known to have four HGVs as of January 2021. The Kinzhal is an air-launched ballistic missile with a nuclear warhead. It has reportedly been evolved from the Russian ground launched Iskander-M.[14] The 8 m long missile has a payload of 450 kg, and range of 2,000 km. It was one among the many "new generation" weapons announced by President Putin in March 2018. Russia had recently deployed two, Kinzhal missile carrying, MiG-31K interceptor aircraft in Syria.[15] Earlier, last year, MiG-31K interceptors had test-fired the Kinzhal missile in a military exercise.

American Hypersonic Weapons Program

The U.S. hypersonic missiles are all getting ready for take-off. Most basic technologies are tested and in place. The NASA wind tunnels are currently having long queues. More are being built. Industrial base for churning out a large number of weapons will be ready by mid 2020s. Funding has been increased to catch up with Russia and China, and prevent asymmetry. Chinese have already been calling the DF-26 as the "Guam Killer". The U.S. is now spending about $3.5 billion annually[16] and developing a portfolio for air, land, and sea launch platforms. The Lockheed Martin AGM-183 ARRW ("Air-Launched Rapid Response Weapon") is boost glide weapon under testing.[17] The early operational capability (EOC) of the missile is targeted for September 2022. Northrop Grumman, and Raytheon Technologies are the other major players. The Pentagon has supported an Applied Hypersonics University Consortium. Under the Joint Hypersonic Transition Office (JHTO), set up in April 2020.

Indian Hypersonic Research and Development

When India's DRDO carried out a successful test of its Hypersonic Technology Demonstrator Vehicle (HSTDV), India became the fourth country after the U.S., China and Russia to develop hypersonic technology.[18] The HSTDV uses scramjet for hypersonic flight. Meanwhile, BrahMos-II is a hypersonic cruise missile under joint development by Indo-Russian joint-venture BrahMos Aerospace Private Limited. The BrahMos-II, is the second series missile and is targeting a range of 1,000 kilometres, and speed of Mach 8, and likely to be inducted by 2025.

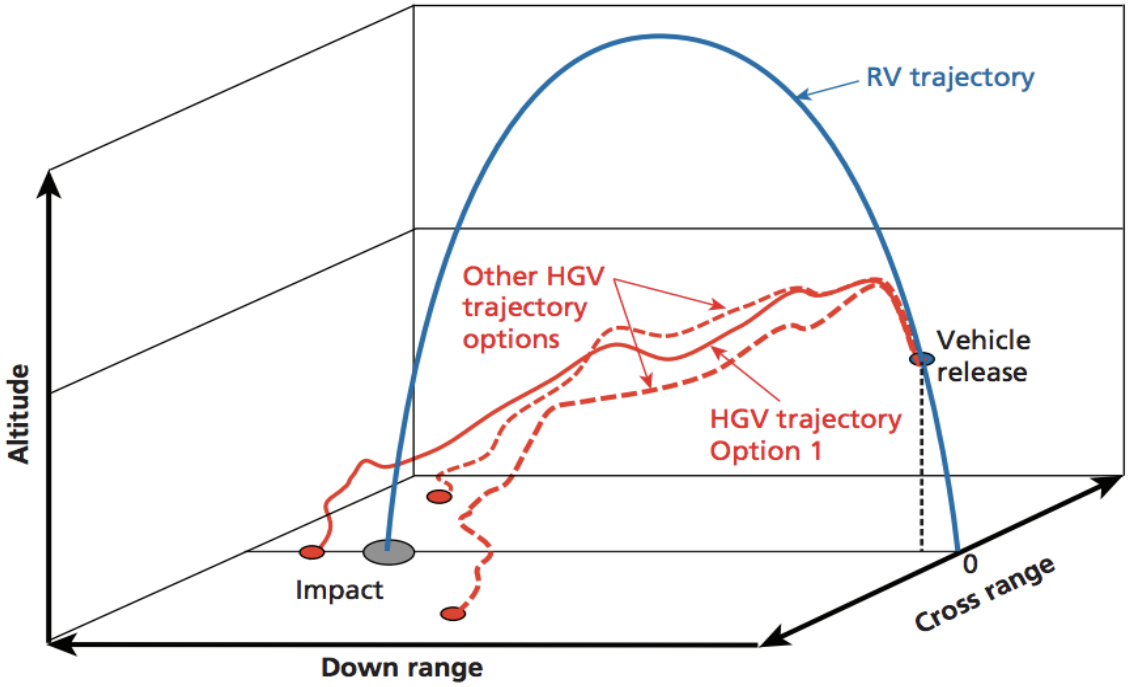
Defence against Hypersonic Weapons

There are many who believe that it is currently not possible to defend against hypersonic weapons because their high speed and continued manoeuvrability. Despite the inherent difficulties of defending against their speed and manoeuvrability, this defenceless stance is unreal. The Ballistic missiles fly to much higher altitudes and follow relatively predictable trajectories. It is therefore possible to detect and follow them for most of their flight using

ground or space based early-warning systems. It is also possible to predict their destination. One gets around 3,000 km (14 minutes) tactical warning. A RAND study[19] suggests that the detection for HGV would be only six minutes prior to impact. Even if detected by a ground-based radar, it will not be easy to predict its destination or target. This brings in an element of surprise and makes hypersonic missiles ideal for concealed and deceptive long-range strikes. They will also be able to penetrate most of the current state-of-the-art air defence systems.

Figure: 1

Ballistic Reentry Vehicle (RV) Versus HGV Trajectories



SOURCE: RAND analysis.

RAND *RR2137-1.3*

Source: Richard H. Speier, George Nacouzi, Carrie A. Lee, Richard M. Moore, Hypersonic Missile Nonproliferation, RAND Corporation, 2017, https://www.rand.org/content/dam/rand/pubs/research_reports/RR2100/RR2137/RAND_RR2137.pdf. Accessed on 10 July 2021.

Some security analysts believe a space sensor layer is the key to meeting the hypersonic threat.[20] To mitigate this problem the United States is researching on such a satellite-sensor layer. These sensors would have to track both, the ballistic missiles and hypersonic vehicles. A constellation of maybe 100s of such satellites would have to be positioned in low earth orbit (LEO). More advanced sensors are expected to be placed into space. Meanwhile Russia and China are working on a next generation over-the-horizon (OTH) radars. These are likely to detect hypersonic missiles at much farther ranges. Among them are the new Russian Konteyner OTH radar and Chinese J27-A OTH[21] Delayed detection, and a degraded decision-making environment may have consequences for threat perceptions, and accidental escalation.

The 'point defence' systems like the U.S. Patriot and Terminal High-Altitude Area Defence (THAAD), Israeli David Sling and Iron Dome, and Russian S-400 are defend against ballistic

missiles, or other projectiles, some of which may actually be moving faster than hypersonic weapons, but their paths are highly predictable. Ballistic missiles do not have ability for manoeuvre that hypersonic missiles have. So, speed in itself, may not be a barrier for missile defence. For a variety of technical reasons, using these SAMs as 'area defence weapons' against hypersonic weapons would be impossible. Meanwhile, Russia is developing the S-500 missile interceptor system, and the United States is working on the THAAD-ER (Terminal High Altitude Area Defence-Extended Range) system.[22] These systems are designed for area defence. Against hypersonic weapons, one requires point defence systems. Deploying S-500 class at many targets would be cost-prohibitive. At best they could defend some critical command and control nodes and some land-based nuclear assets. A lot is being talked of, and research is in progress, to use directed-energy and laser weapons to defend against hypersonic weapons. But this is work still in progress.

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Hypersonic Threat to High Value Assets

Hypersonic weapons are likely to be used against high value targets like aircraft carriers. In view of scarce funds, the debate over the efficacy of carriers in high-end conflict continues. The Gerald R. Ford-class aircraft carrier costs around US$ 12 billion. As per some estimates, the Indian Navy plans to acquire its third aircraft carrier for a whopping Rs 1.6 lakh crore[23] ($21.48 billion), including fighter aircraft.

Initial eight hypersonic missiles for the U.S. test program are expected to have cost at least $1.1billion.[24] In the long run the average cost of the missile could be around $100 million. The missiles' kinetic energy at the time of impact, at speeds of at least 1,150 miles per hour,[25] makes them powerful enough to penetrate any building material or armoured plating with the force of three to four tons of TNT. An attack by 5-6 HCM could easily sink an aircraft carrier. It would be a catastrophic loss, and greatly reduce adversaries' operational capability and would sink the force morale.

For the cost of an aircraft carrier, one could buy nearly 2,000 precision HCM. The potency of the two needs to be analysed. Hypersonic weapons could be the new equivalent of nuclear deterrence and their use considered highly escalatory. Such prompt strike weapons could be a good investment. While many navies, including Indian, continue to invest in aircraft carriers, some analysts feel the need to reconsider, and shift the fleet's resources to other potent capabilities including investments in hypersonic weapons.

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Of course, die-hard naval aviators continue to propagate that finding a manoeuvring aircraft carrier, thousands of kilometres deep in the ocean, is not easy. Also, new weapons find new defence responses, as it happened against submarines, and imilarly, defence solutions against HCM will evolve. Directed energy weapons are a likely option. The world is pursuing hypervelocity projectiles launched from electromagnetic rail-guns. They are smaller and cheaper, and ships could carry many of those.

Indian HCM should act as a deterrent against high value targets such as Chinese aircraft carriers which are set to foray into Indian Ocean. The bottom line is that hypersonic weapons will determine who is 'precise and 'prompt' enough in 21st-century conflict.

Way Ahead for India

It is becoming clear that conventional hypersonic weapons will make a big change in the combat environment, and have significant deterrent value. Like many other disruptive technologies that are bringing military transformation, such as Artificial Intelligence (AI), cyber warfare, hypersonic weapons will influence to change the status quo. India has begun investing in hypersonic technologies and systems. BrahMos II is likely to be the first HCM. Larger HGVs and HCMs will be required. Indian HCM should act as a deterrent against high value targets such as Chinese aircraft carriers which are set to foray into Indian Ocean. The bottom line is that hypersonic weapons will determine who is 'precise and 'prompt' enough in 21st-century conflict. India has to get its act right invest in hypersonic technologies in a big way. It must also invest in developing defensive systems against hypersonic weapons. A dedicated team under a very aggressively driving able program manager should be formed. The progress must be monitored at the highest level. With the three great powers heavily committed into hypersonic weapons, there is no stopping this arms race. The best option for India against the Chinese hypersonic programs is to develop similar systems and hold the adversary to equivalent risk.

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