CENTRE FOR JOINT WARFARE STUDIES

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THE HYPERSONIC HYPE

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Russia's Defense Ministry said three MiG-31 fighters with Kinzhal hypersonic missiles arrived at the Chkalovsk air base in the Baltic Sea territory as part of "additional measures of strategic deterrence." Media Report 18 Aug 2022

Introduction

The world woke up to hypersonic arms race with China launching the hypersonic glide vehicle and North Korea boasting of hypersonic missile. India also heralded its entry into the hypersonic technology demonstrator club by successfully launching her first vehicle in Sep 2020. Today, **the USA, China and Russia** have the most advanced hypersonic weapon capabilities with France, Germany, India, Japan, Australia, and North Korea staking claims to have tested a hypersonic missile as technology demonstrators.

Little did Wright Brothers know, in 1903, that their powered flying machine will be a subject of technology upgrade and innovation. Continuing the odyssey of quest for speed, the sonic sound barrier was broken on 14 Oct

1947 by Maj Chuck Yeager flying the Bell X-1 rocket followed by US WAC Corporal sounding rocket to become the first object of human origin to go hypersonic!

The Challenge of Hypersonic

Hypersonic systems fly at a speed above‘one mileper second’, classically five times the speed of sound or five Machs. The challenges of breaking the hypersonic sound barrier are immense. At hypersonic speeds, the air molecules that envelope the flight vehicle change, breaking apart and gaining a charge in a process called ionization. This subjects the hypersonic vehicle to “tremendous” stresses as it pushes through the atmosphere generating a massive heat flux. In fact, hypersonic systems, be they aircraft or missiles, present a complex set of engineering and support system technological challenges – scorching heat of over 1100 degrees C, advanced materials for structural strength to with stand extremely high temperatures and hence, the need for thermal management, propulsion systems to sustain speeds, guidance and control systems to meet the stringent accuracy of these strategic weapon systems. These are in addition to the standard design and development complications of missile systems of form factor space management, miniaturization, sophisticated power management, light weight and dynamic stability of the missile systems.

The R & D in hypersonics is a big challenge. Very few Nations, in general, and Institutions, in particular, have the hypersonic wind tunnels and environmental chambers to simulate and test mechanical stresses, high speed electronics, associated EMI /EMC and the high costs.

Why Hypersonic Platforms

Combat aircraft and missile systems are ruggedized to meet the rigorous vagaries of battlefield and governed by four competing requirements - maneuver, protection, stealth and fire power. The governing KPI is survivability. High mobility is considered as an inherent protection.

The aerial platforms both aircrafts and missiles are extremely maneuverable combat systems with high mobility.Speaking of missiles and rockets, these may be ballistic or cruise. Ballistic missiles are typical projectiles in which the range is a function of speed and altitude and may follow a pure or

modified ballistic trajectory. There is a boost phase where the missile rises to altitudes of 30 kms or more, the propulsion system switch off and the missile re-enters the earth's atmosphere at speeds over Mach 5 and either falls like a stone in aballistic trajectory or is maneuvered through a predefined modified trajectory by wings and other control surfaces. These are used to configure a ballistic Missile Defence System in a seeker shooter configuration to protect critical assets.

In contrast, cruise missile systems are powered throughout the trajectory. Hypersonic weapon systems, may fly at over 20 Machs, are fast, agile systems designed to beat any ballistic missile defence (BMD) by sheer speed and maneuver. While aircrafts have an inherent human limitation of 8G maneuver, missiles can maneuver beyond 20G based on the structural strength.

Yet another potential use of HGV is for Intelligence, Surveillance and Reconnaissance (ISR) though the technologies to capture and display information at that speed are still under design and development.

The major advantage of Hypersonic systems is that detection of these missiles and glide vehicles is a challenge. A series of space based surveillance devices would be required to be able to detect and track-atechnology which is still a R & D challenge.

The Hypersonic Platforms

Hypersonic platforms are two main types – glide vehicles and cruise missiles. The former is a preferred vehicle, since these are launched from a rocket before gliding to their target and obviate the challenges of achieving hypersonic propulsion of missiles. Viewing from the technology lens, the first big ticket is the propulsion system. Hypersonic missiles have engines advance ram jets and supersonic combustion ram jets or scramjets that use oxygen in the air and mix these with hydrogen fuels to produce thrust during their flight, allowing them to cruise at a steady speed and altitude. The hypersonic propulsion system may comprise solid or liquid propellants or a combination or a dual combustion ramjet for configuring a precise control system. The solid propulsion systems are normally used in the boost phase and the liquid for the cruise phase for precise manoeuvre. The critical design parameters hinge around the propellant design and nozzle design.

Rare earth coatings like platinum are imperative for imparting structural integrity to the nozzles for enhanced performance under extreme thermal and mechanical stresses. There is a trade off between the explosive payload and propulsion to balance out the range with the terminal effect. The all up weight needs a very balanced optimisation. Hence, the airframe has to be light weight but have the structural strength to withstand the aerodynamic forces and the intense heat. Aluminium alloys titanium, steel, magnesium, reinforced silicon, piezo electric fibres are advanced materials and the heat shrinkable heat shield is achieved with modified silicon rubber, carbon reinforced composites, specially at the radome head for better thermal management.

The guidance control system is the brain of the missile system comprising on board computer, inertial measurement unit (IMU) and control surfaces for precision and positioning of the missile accurately as it maneuvers to the target. In liquid propulsion engines, the gimballed engines provide the requisite thrust and thrust vector control. This is the crux of the hypersonic hype. An extremely agile missile system, high technology and high cost, difficult to defeat, must be accurate to be effective at the target end. For this purpose, a well-tuned IMU for following the desired precise trajectory supported by a responsive control system with near zero latency and real time terminal guidance through image recognition is imperative to achieve near zero circular error of probability (CEP). The hypersonic glide vehicle and hypersonic missile are programmed for precise positioning on high value targets.

But the moot question arises How much payload (Warhead) is delivered at the target end 500 kg, 1000 kg or more. This is the designers challenge in optimizing payload which is the crux of the Hypersonic platform.

Global Hypersonic Scenario

Hypersonic weapons (HW) are at the centre of escalating competition between the USA, China and Russia.The HW Arms Race is gaining traction, in long range Hypersonic Cruise Missiles and Hypersonic Glide Vehicles (HGVs). In fact, the HGVs ride on ICBMs to create disruption in strategic targeting. India, Germany, France Japan and North Korea are progressing intensive testing of Hypersonic Missiles. Though technology demonstrators there is promise in the proliferation and application as a HGV with long range ICBMs, IRBMs and MRBMs.

China has made rapid progress in hypersonic glide vehicles and missiles. They have conducted a number of successful tests of the DF -41, an ICBM, and DF-17, a medium-range ballistic missile (MRBMs), designed to launch hypersonic glide vehicles capable of carrying varied warheads. In fact, the Chinese Hypersonic glide vehicle DF ZF can be fitted on a number of ICBMs and MRBMs for effective strategic target engagements. DF ZF has a low trajectory making detection nearly impossible. Reportedly the Chinese also conducted possibly two hypersonic weapons tests over last summer, including the launch into space of an orbiting hypersonic weapon as a re-useable space vehicle, capable of carrying a nuclear payload.

Russia has three Hypersonic Weapon Platforms, Avanguard the Russian hypersonic glide vehicle, Kinzhal hypersonic air launched ballistic missile system and Tsirkon Hypersonic Cruise Missile. Avangard can be launched from an ICBM or ship launched and reportedly capable of carrying both conventional a nuclear warhead. Russia is also claimed to have employed hypersonic weapons, in the form of Kinzhal missiles on weapon and fuel dumps, for the first time in combat in Ukraine. Though the Kinzhal travels at hypersonic speeds, it is a ballistic missile and does not fall into the classical category of hypersonic weapons.

USA has been under peer competition from China and Russia to develop hypersonic technologies. The hypersonic glide vehicles are developed for ICBMs, Navy and Air Force for long range engagements. DARPA Projects on air launched cruise hypersonic missiles is under progress and 15 Billion USD are reportedly pledged between 2015 -2024 development window.The Tomahawk Cruise Missile demonstrated the nearly perfected the terminal guidance which could be progressively adopted for Hypersonic Weapon Systems. Feeling the heat of competition with China and the high costs of R &D, a consortium approach by AUKUS comprising the UK, USA and Australia are cooperating on ‘hypersonics and counter-hypersonics’ as part of their security pact to develop higher performing and affordable systems.

India has huge security responsibility as an Asian Regional Power Centre more so in view of China which has always been the bigger challenge in the fast changing Indian Ocean and Indo Pacific Region calculus. Indian Hypersonic Missile Program comprisea HypersonicTechnology Demonstrator Vehicle (HSTDV) – a HGV, Shaurya Hypersonic Missile, an

aeroballistic missile Rudram 3, BrahMos II of the Indo Russian JV BrahMos Missile System akin to Hypersonic Cruise Missile Tsirkon of Russia.

Dual Use Hypersonics

Hypersonic Technologies have been in news since time immemorial in space missions. A competition in the peaceful tech race to Marsand outer space exploration and travel,is now extending to faster inter-continental travel. The technology demonstrators include US X 15, US XCOR Lynx, US Boeing X 51 Wave Rider and X 43, UK Rel Skylon and Germany Sharp Edge Flight Experiment (Shefex) and of course, the Indian HSTDV among others.The Supersonic British Airways-Air France Concorde flights gave speedier travel a maiden venture till it was discontinued on rising maintenance cost. In the connected global ONE WORLD where distance is measured in terms of time taken in travel, hypersonic commercial airplanes is great future proposition. Extensive research on supersonic and hypersonic speed travel is underway on how to dampen the effects of crossing a series of sound barriers to create a comfortable passenger experience.

The Value Proposition

Hypersonic Eco System is the next disruption in aircraft design and missile technologies. It is a long shot – 2035 and beyond. The immense future use in outer space for travel and exploration, inter-continental travel and military use makes hypersonics a prime technology stack for R & D. The intent is to produce less expensive and affordable technologies to launch, glide aerial hypersonic platforms, tech stack to collect collate and display real time ISR actionable info for military use, and have safer hypersonic designs for comfortable travel as a civilian use. A resurgent Aatmanirbhar India is ready to embrace nextgen technological challenges – consortium approach with AUKUS may be the value proposition!

There is an interesting debate - Hypersonic Hype is either real and a gamechanger for deterrent effect, an idea whose time has arrived or an unnecessary technological mirage, economic burden with minimal integral impact on military capabilities. It is a paradigm of National political will, technology thresholds and economy of scales. But for sure it qualifies as a technology which is neighbours envy - owners pride!

What is the Indian Paradigm! We have demonstrated the technology and the firm political will. It is estimated that a single hypersonic missile may cost over 100 Million USD against approximately 3 Million USD cost of one BrahMos Missile. In physical terms one can pulverise a target with at least thirty times explosive payload. The defining parameters, therefore, are - Where is hypersonic technology development in the National Security and Technology Strategy, how these are postured for dual use, how these are developed and leveraged fora geostrategic impact.The moot question is – Given the Indian Space and Military Programs driven byGovernment and Corporate do we, should we and can we posture to lead the global race ! The jury is out. India must hasten slowly.

CERTIFICATE

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