



Hypersonic Technology

Why in News

Recently, it has been reported that **China tested a nuclear-capable hypersonic glide vehicle** that circled the globe before speeding towards its target.

- Several countries, including the **US, Russia and China**, are developing **hypersonic missiles** which travel at a speed five times that of sound.
- Though **slower than ballistic missiles**, they are harder to intercept and can be manoeuvred.

Key Points

▪ Implications for India:

- Hypersonic technology developments, in the backdrop of **growing US-China rivalry** and a year-long **standoff with Indian forces in eastern Ladakh**, is certainly a threat for India's space assets along with the surface assets.
- The offence system operating at these speeds would **mean a requirement to develop defence systems at these speeds.**

▪ Hypersonic Speed and Technology:

◦ About:

- Hypersonic speeds are **5 or more times the Mach or speed of sound.**
- **Mach Number:** It describes an aircraft's speed compared with the speed of sound in air, with Mach 1 equating to the speed of sound i.e. **343 metre per second.**

◦ Types (2):

- **Hypersonic cruise missiles:** These are the ones that **use rocket or jet propellant** through their flight and are regarded as being just faster versions of existing cruise missiles.
- **Hypersonic Glide Vehicle (HGV):** These missiles first go up into the atmosphere on a conventional rocket before being launched towards their target.
- **Technology Used:** Most hypersonic vehicles primarily use the **scramjet technology**, which is a type of **Air Breathing propulsion System.**
 - This is extremely complex technology, which also needs to be able to handle high temperatures, making the hypersonic systems extremely costly.

Ballistic Missile vs Cruise Missile

Ballistic Missile	Cruise Missile
<ul style="list-style-type: none">▪ Travel in projectile motion and trajectory depends on gravity, air resistance and Coriolis Force.	<ul style="list-style-type: none">▪ Comparatively follows a straight trajectory of motion.
<ul style="list-style-type: none">▪ Leave the earth's atmosphere and re	<ul style="list-style-type: none">▪ The flight path is within the earth's

enter it.	atmosphere.
<ul style="list-style-type: none"> ▪ Long-range missiles (300 km to 12,000 km) 	<ul style="list-style-type: none"> ▪ Short range missiles (range upto 1000 km)
<ul style="list-style-type: none"> ▪ E.g. Prithvi I, Prithvi II, Agni I, Agni II and Dhanush missiles. 	<ul style="list-style-type: none"> ▪ E.g. BrahMos missiles

Classification of Missiles Based on Speed

Speed Range	Mach Number	Velocity in m/s
Subsonic	< 0.8	< 274
Transonic	0.8-1.2	274-412
Supersonic	1.2-5	412-1715
Hypersonic	5-10	1715-3430
High-hypersonic	10-25	3430-8507

▪ Development of Hypersonic Technology in India:

- **India**, too, is working on hypersonic technologies.
 - As far as space assets are concerned, India has already proved its capabilities through the test of [ASAT under Mission Shakti](#).
- Hypersonic technology has been developed and tested by both DRDO and ISRO.
- Recently, DRDO has successfully flight-tested the [Hypersonic Technology Demonstrator Vehicle \(HSTDV\)](#), with a capability to travel at 6 times the speed of sound.
- Also, a **Hypersonic Wind Tunnel (HWT)** test facility of the DRDO was inaugurated in Hyderabad. It is a pressure vacuum-driven, enclosed free jet facility that simulates Mach 5 to 12.

Air Breathing Propulsion System

- **About:** These systems **use atmospheric oxygen**, which is available up to about 50 km of earth's surface to burn the fuel stored on-board thereby making the system much lighter, more efficient and cost effective.
- **Examples** of Air Breathing Propulsion System include the Ramjet, Scramjet, Dual Mode Ramjet (DMRJ).
- **Ramjet:**
 - A ramjet is a form of air breathing jet engine that uses the vehicle's forward motion to compress incoming air for combustion without an axial compressor.
 - Fuel is injected in the combustion chamber where it mixes with the hot compressed air and ignites.
 - Ramjets **cannot produce thrust at zero airspeed**; they cannot move an aircraft from a standstill.
 - A ramjet-powered vehicle, therefore, **requires an assisted take-off**, like a rocket assist, to accelerate it to a speed where it begins to produce thrust.
 - The ramjet **works best at supersonic speeds** and as the speed enters the hypersonic range, its efficiency starts to drop.
- **Scramjet:**
 - A scramjet engine is **an improvement over the ramjet engine** as it operates at

hypersonic speeds and allows supersonic combustion, which gives it its name — **supersonic combustion ramjet, or scramjet.**

- The scramjet is composed of **three basic components:**
 - A converging inlet where incoming air is compressed,
 - A combustor where gaseous fuel is burned with atmospheric oxygen to produce heat,
 - A diverging nozzle where the heated air is accelerated to produce thrust. The exhaust gases are accelerated to hypersonic speeds using a divergent nozzle.
- The speed at which the vehicle moves through the atmosphere causes the air to compress within the inlet. As such, **no moving parts are needed in a scramjet**, which reduces the weight and the number of failure points in the engine.

▪ **Dual Mode Ramjet (DMRJ):**

- The third concept is **a mix of ramjet and scramjet**, which is called DMRJ.
- There is a need for an engine which can operate at both supersonic and hypersonic speeds.
- A DMRJ is an engine design where a ramjet transforms into a scramjet over Mach 4-8 range, which means, it can operate in both the subsonic and supersonic combustor mode.

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