

# **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 <u>US-China rivalry</u> and a year-long <u>standoff with Indian forces in eastern Ladakh</u>, 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> <li>Travel in projectile motion and trajectory depends on gravity, air resistance and Coriolis Force.</li> </ul>	<ul> <li>Comparatively follows a straight trajectory of motion.</li> </ul>	
Leave the earth's atmosphere and re	The flight path is within the earth's	

enter it.	atmosphere.
<ul> <li>Long-range missiles (300 km to 12,000 km)</li> </ul>	<ul> <li>Short range missiles (range upto 1000 km)</li> </ul>
<ul> <li>E.g. Prithvi I, Prithvi II, Agni I, Agni II and Dhanush missiles.</li> </ul>	<ul> <li>E.g. BrahMos missiles</li> </ul>

#### **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 <u>ASAT under Mission Shakti</u>.
- Hypersonic technology has been developed and tested by both DRDO and ISRO.
- Recently, DRDO has successfully flight-tested the <u>Hypersonic Technology</u> <u>Demonstrator Vehicle (HSTDV</u>), 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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