Hypersonic technology demonstrator vehicle (HSTDV)

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Manifest pedagogy

India is marching ahead with a lot of first-of-its-kind indigenous developments in the field of launch vehicles and missiles. Whenever such a feat is accomplished, it has to be added to the notes of an aspirant. It may appear as a direct question or the same can be used as an example in the mains answers under the India's technology achievements.

In news

- Defence Research and Development Organisation (DRDO) conducted the maiden test of an indigenously developed Hypersonic Technology Demonstrator Vehicle (HSTDV).

Placing it in syllabus

- Indigenisation of Space technology

Static dimensions

- Hypersonic technology
- Scramjet technology
- Cruise and ballistic missiles
- Hypersonic cruise missile under development

Current dimensions

- HSTDV

Content

DRDO recently conducted the first on-field test of its **hypersonic unmanned scramjet cruise missile** and marked the first real-world test of the hypersonic vehicle using a

reusable solid booster first stage. The only other countries that possess this technology are the **US, Russia and China**. The aim of the mission was to “prove a number of critical technologies for futuristic missions”.

Hypersonic technology

- Hypersonic weapons incorporate the speed of a ballistic missile with the manoeuvring capabilities of a cruise missile.
- They travel **faster than Mach 5** (~3,800mph) (faster than that of sound) and have the capability to manoeuvre during the entire flight and follows a smooth flight path, which is much harder to track than that of traditional missiles.
- Are specifically designed for increased survivability against modern ballistic missile defense systems.
- They are capable of delivering conventional or nuclear payloads at ultra-high velocities over long ranges.
- Hypersonic vehicles typically consist of a Supersonic Combustion Ramjet, or Scramjet propulsion system to enable such high speeds.
- They are delivered in two ways

(1) they can be fired from the last stages of Intercontinental Ballistic Missiles (ICBM) or Submarine-Launched Ballistic Missiles (SLBM) and skip along the top of the atmosphere using specialised jet engines to accelerate to hypersonic speeds.

(2) they can be launched independently or released from a bomber similar to cruise missiles before accelerating to ultra-high speeds.

Scram-jet technology

Today, satellites are launched into orbit by multi-staged satellite launch vehicles (SLV) that can be used only once (expendable). Nearly 70% of the propellant (fuel-oxidiser combination) carried by today’s launch vehicles consists of

oxidiser. Thus the future **re-usable launch vehicle** concept along with air-breathing propulsion reduces the cost. Ramjet, Scramjet and Dual Mode Ramjet (DMRJ) are the three concepts of air-breathing engines which are being developed by various space agencies.

Ramjets work most efficiently at supersonic speeds around Mach 3 (three times the speed of sound) and can operate up to speeds of Mach 6. It carries liquid oxygen (oxidiser) and hydrogen together, adding a tremendous amount of weight to the vessel. However, the ramjet efficiency starts to drop when the vehicle reaches hypersonic speeds.

A scramjet engine is an improvement over the ramjet engine as it efficiently operates at hypersonic speeds and allows supersonic combustion. Thus it is known as **Supersonic Combustion Ramjet, or Scramjet**. A Scramjet uses "air breathing" technology. This means that the engine collects oxygen from the atmosphere as it is traveling and mixes the oxygen with its hydrogen fuel, creating the combustion needed for hypersonic travel.

For a scramjet to work the air traveling into the engine must already be at supersonic speed. This is so the air is properly condensed to the required density to effectively combust with the hydrogen mix. To reach supersonic speed, the vessel is usually launched with a traditional booster engine, and once it has reached the proper speed and altitude (generally around Mach 5 and 100,000ft) the scramjet is activated. **India is the fourth country to have Scramjet Engine technology after USA, Russia and China.**

Cruise missile and ballistic missile

- A **cruise missile** is a guided missile used against terrestrial targets, that remain in the atmosphere and flies the major portion of its flight path at approximately constant speed.

- Cruise missiles are designed to deliver a large warhead over long distances with high precision.
- Modern cruise missiles are capable of travelling at supersonic or high subsonic speeds, are self-navigating, and are able to fly on a non-ballistic, extremely low-altitude trajectory.
- They stay relatively close to the surface of the earth to avoid detection from anti-missile systems.
- The missile is guided entirely to the target under its own power.

Ballistic Missile

- A ballistic missile is targeted as a projectile from a single launch force with not much-added guidance.
- It is launched directly into the high layers of the earth's atmosphere.
- It travels well outside the atmosphere and then the warhead detaches and falls back to earth.
- Since it depends on gravity to reach its target, it's called a ballistic missile.
- Ballistic missiles that fly above the atmosphere have a much longer range than would be possible for cruise missiles of the same size.
- Ballistic missiles can travel extremely quickly along their flight path.
- Ballistic missiles are much harder to intercept than cruise missiles, due to the much shorter time available.
- Long- and medium-range ballistic missiles are generally designed to deliver nuclear weapons because their payload is too limited for conventional explosives to be cost-effective.

India has been developing a range of cruise missiles and ballistic missiles to meet its security challenges under the **Integrated Guided Missile Development Programme**. These include the Prithvi and Agni missiles as well as the anti-tank Nag and surface to air Akash. India in collaboration with Russia has

developed the Brahmos cruise missile. Recently, India successfully carried out an **anti-satellite missile** test that aims to protect its space assets.

More about HSTDV

The HSTDV cruise vehicle is mounted on a solid rocket motor, which will take it to a required altitude, and once it attains certain mach numbers for speed, the cruise vehicle will be ejected out of the launch vehicle. The double-wall engine is built using a **Niobium alloy**, which has a high thermal latency, and can therefore withstand the high combustion temperature and pressures inside the engine chamber. The HSTDV is designed to eventually reach production target of Mach 6.5 speeds at an altitude of 32,500 metres. This would give the cruise missile a total flight impact distance of nearly 45km, within impact time of just 20 seconds.

Significance

- It is significant in both security and technological grounds.
- Security-wise, a hypersonic cruise missile can be key in taking out hostile airborne attacks, giving the Air Force an edge in terms of launching offensive attacks of their own.
- Technology- wise it can be incorporated into other areas such as sweeping surveillance tasks.
- In case of defence, it can be used to intercept incoming missiles in the outer atmosphere or in the inner atmosphere.
- It will help add to India’s ballistic missile defence capabilities.
- It is energy-efficient, low cost and aids in developing reusable satellite-launch vehicle.
- Commercial usage designs can be developed if the combustion model is harnessed which in turn can aid areas such as reusable spaceflight and more efficient

commercial cargo transmission.

Hypersonic cruise missile under development

- BrahMos-II or BrahMos-2 or BrahMos Mark II is a hypersonic cruise missile currently under joint development by Russia’s NPO Mashinostroyenia and India’s DRDO.
- It is the second of the BrahMos series of cruise missiles.
- The BrahMos-II is expected to have a range of 450 kilometres and a speed of Mach 7. During the cruise stage of flight the missile will be propelled by a scramjet air-breathing jet engine.
- The planned operational range of the BrahMos-II has been restricted to 290 kilometres as Russia is a signatory to the **Missile Technology Control Regime (MTCR)**, which prohibits it from helping other countries develop missiles with ranges above 300 kilometres.
- Now as **India is also a MTCR signatory**, it is trying to extend the range of BrahMos.
- It has been described as the fastest cruise missile in the world.
- BrahMos Aerospace named the missile BrahMos-II in honour of the former President of India, APJ Abdul Kalam.