



LAST MINUTE PRELIMS RECKONER 2025

SCIENCE & TECHNOLOGY

SATELLITE LAUNCH VEHICLES OF INDIA

SATELLITE LAUNCH VEHICLES OF INDIA

- ✓ **Active operational launch vehicles:**
 - Geosynchronous Satellite Launch Vehicle (GSLV)
 - Geosynchronous Satellite Launch Vehicle Mk-III (LVM3)
 - Polar Satellite Launch Vehicle (PSLV)
 - Sounding Rockets
- ✓ **Launchers under development:**
 - Human Rated Launch Vehicle (HRLV)
 - Small Satellite Launch Vehicle (SSLV)
 - Reusable Launch Vehicle – Technology Demonstrator (RLV-TD)
 - Scramjet Engine – TD
- ✓ **Retired:**
 - Satellite Launch Vehicle-3 (SLV-3)
 - Augmented Satellite Launch Vehicle (ASLV)

GEOSYNCHRONOUS SATELLITE LAUNCH VEHICLE MARK II (GSLV Mk II)

- ✓ **Fourth generation** launch vehicle
- ✓ Developed to **launch communication satellites** using cryogenic third stage
- ✓ Capability of placing up to **6000 kg in Low Earth Orbits** and **2,250 kg in Geosynchronous Transfer Orbits**
- ✓ **Three stage vehicle:**
 - First Stage:
 - **Solid rocket motor** is augmented by 4 liquid strap-ons.
 - Second Stage:
 - Uses a **liquid rocket engine** called the **Vikas engine**, developed by Liquid Propulsion Systems Centre
 - Third stage:
 - Uses the **cryogenic engine** developed by the Liquid Propulsion Systems Centre
- ✓ Primary payloads are **INSAT class of communication satellites** that operate from **Geostationary orbits**

CRYOGENIC ENGINE:

- ✓ In physics, cryogenics is the production and behaviour of materials at **very low temperatures**.
- ✓ Cryogenic engines use of **Liquid Oxygen (LOX)** and **Liquid Hydrogen (LH2)** as propellants, which liquefy at -183 °C and -253 °C respectively.
- ✓ The **United States, Russia, Japan, India, France and China** are the only countries that have operational cryogenic rocket engines.
- ✓ ISRO's **Cryogenic Upper Stage Project (CUSP)** envisaged the design and development of the indigenous Cryogenic Upper Stage.



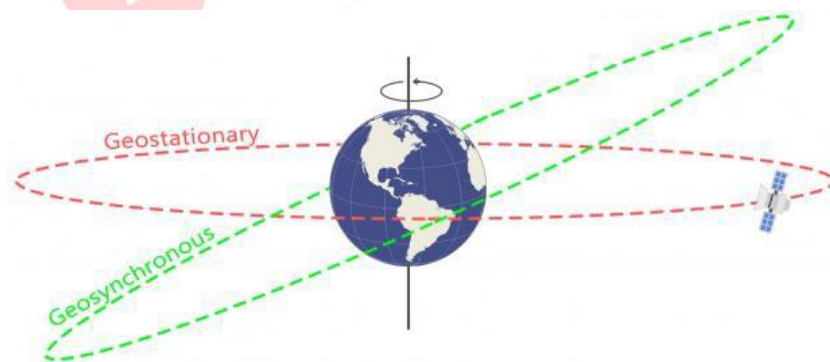
GEOSYNCHRONOUS SATELLITE LAUNCH VEHICLE MARK III (LVM3)

- ✓ Heavy lift launch vehicle of ISRO. Used for **Chandrayaan 3**.
- ✓ Capable of placing the **4 tonne class satellites** into Geosynchronous Transfer Orbits and **8000 kg in Low Earth Orbits** of 600 km altitude
- ✓ **Three stage vehicle:**
 - First Stage:
 - Solid Rocket Boosters:
 - Uses two solid rocket boosters to provide the huge amount of thrust required for lift off
 - Core Stage: Liquid Stage
 - Powered by two Vikas engines
 - Cryogenic Upper Stage:
 - Powered by CE-20, India's largest cryogenic engine



GEOSTATIONARY AND GEOSYNCHRONOUS ORBITS:

- When a satellite reaches about 36,000 kilometers from Earth's surface, it enters a "sweet spot" in which **its orbit matches Earth's rotation**. This high Earth orbit is called geosynchronous.
- A spacecraft in geosynchronous orbit **appears to remain above Earth at a constant longitude**.
- Geosynchronous satellites are useful for telecommunications and other remote sensing applications.
- Geostationary orbits fall in the same category as geosynchronous orbits, but **the orbit lies on the same plane as the equator**.
- Weather monitoring satellites use geostationary orbits because it gives a constant view of the same area.



POLAR AND SUN-SYNCHRONOUS ORBITS:

- Satellites in polar orbits **travel past Earth from north to south, passing roughly over Earth's poles**.
- Polar orbits are a type of **low Earth orbit**
- Sun-synchronous orbit (SSO) is a particular kind of polar orbit.
- Satellites in SSO are synchronised to always be in the same 'fixed' position relative to the Sun. Hence, the **satellite always visits the same spot at the same local time**.

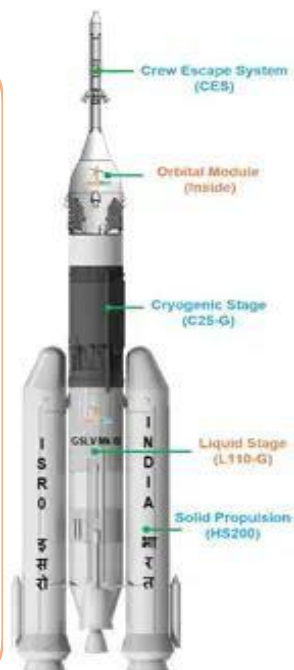
POLAR SATELLITE LAUNCH VEHICLE (PSLV): 'The Workhorse of ISRO'

- ✓ **Third generation** launch vehicle of India
 - ✓ First Indian launch vehicle to be equipped with liquid stages
 - ✓ **4 stage vehicle:**
 - First Stage:
 - uses the S139 **solid rocket motor** and **6 solid strap-on boosters**
 - Second Stage:
 - Uses a **liquid rocket engine** called the **Vikas engine**, developed by Liquid Propulsion Systems Centre
 - Third Stage:
 - Uses a **solid rocket motor**
 - Fourth Stage:
 - Uses two **liquid engines**
 - ✓ Multiple satellite launch capability and multiple orbit capability
 - ✓ Can take up to **1,750 kg of payload to Sun-Synchronous Polar Orbits of 600 km altitude**. Used to launch various satellites into **Geosynchronous and Geostationary orbits**
- Notable launches:** Chandrayaan-1, Mars Orbiter Mission
- ✓ The **XL version** is launched with **additional propellant in the strap-on solid rocket boosters**, allowing for a larger payload capacity. The PSLV XL rocket was used for the **launch of the Aditya L1 Mission**.



HUMAN RATED LAUNCH VEHICLE (HRLV)

- ✓ **LVM3 rocket** is identified as the launch vehicle for **Gaganyaan mission**.
- ✓ All systems in **LVM3 launch vehicle** are **re-configured** to meet human rating requirements and christened **Human Rated LVM3**.
- ✓ HLVM3 will be capable of launching the **Orbital Module** to an intended **Low Earth Orbit of 400 km**.
- ✓ Orbital Module will **orbit the Earth** and is equipped with state-of-the-art avionics systems.
- ✓ Orbital Module comprises of:
 - **Crew Module:** the habitable space with Earth like environment in space for the crew
 - **Service Module:** will be used for providing necessary support to CM while in orbit
- ✓ HLVM3 consists of **Crew Escape System (CES)** which ensures that Crew Module along with crew is taken to a safe distance in case of any emergency either at launch pad or during ascent phase.

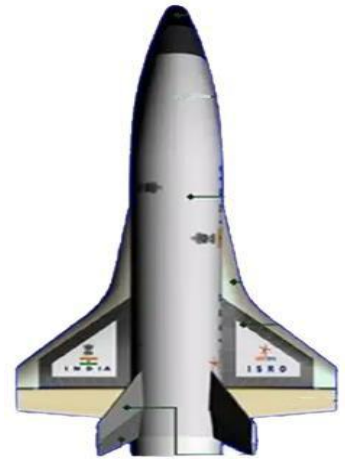


GAGANYAAN:

- India's **maiden human space flight mission** – it envisages demonstration of human spaceflight capability by launching crew of **3 members to an orbit of 400 km for a 3 days mission** and bring them back safely to earth, by **landing in Indian sea waters**.
- It is targeted to be launched in 2025 using an LVM3 Rocket.

REUSABLE LAUNCH VEHICLE – TECHNOLOGY DEMONSTRATOR (RLV-TD)

- ✓ RLV-TD is an endeavour of ISRO towards developing essential technologies for a fully reusable launch vehicle to enable low-cost access to space
- ✓ Configuration is **similar to that of an aircraft** and combines the **complexity of both launch vehicles and aircraft**.
- ✓ The winged RLV-TD will be used to develop technologies like **hypersonic flight (HEX)**, **autonomous landing (LEX)** and **powered cruise flight**.
- ✓ In the future, this vehicle will be scaled up to become the first stage of India's **reusable two-stage orbital (TSTO) launch vehicle**.



SMALL SATELLITE LAUNCH VEHICLE (SSLV)

- ✓ **3 stage Launch Vehicle** configured with three Solid Propulsion Stages and **liquid propulsion-based Velocity Trimming Module (VTM)** as a terminal stage
- ✓ **Payload Capability**
 - Single/Multi Satellites - **Nano, Micro and Mini satellites**
 - Single Satellite up to 500kg in 500km planar orbit
 - Three Multiple satellites ranging from 10kg to 300kg into 500km Planar Orbit
- ✓ **Features of SSLV:**
 - Launch on demand feasibility
 - Low cost, with low turn-around time
 - Flexibility in accommodating multiple satellites
 - Minimal launch infrastructure requirements
- ✓ In Feb 2024, the PM laid the foundation stone for a **new spaceport at Kulasekarapattinam** in southern Tamil Nadu. It will focus on the **launch of SSLVs on a commercial basis for the private sector**. This spaceport will help save fuel for small rocket launches because it **can launch rockets directly south over the Indian Ocean without requiring crossing landmasses**.
- ✓ This is unlike the existing launch site at the Satish Dhawan Space Centre, which adds more fuel requirements for launching into a polar orbit as rockets need to follow a curved path to the south to avoid Sri Lanka's landmass.



SOUNDING ROCKETS

- ✓ **One or two stage solid propellant rockets**
- ✓ Used for probing the upper atmospheric regions and for space research
- ✓ Also serve as **affordable platforms to test prototypes** intended for use in launch vehicles and satellites
- ✓ Launch of the first sounding rocket '**Nike Apache**' from Thumba in Kerala on 21 November 1963, marked the beginning of the Indian Space Programme.



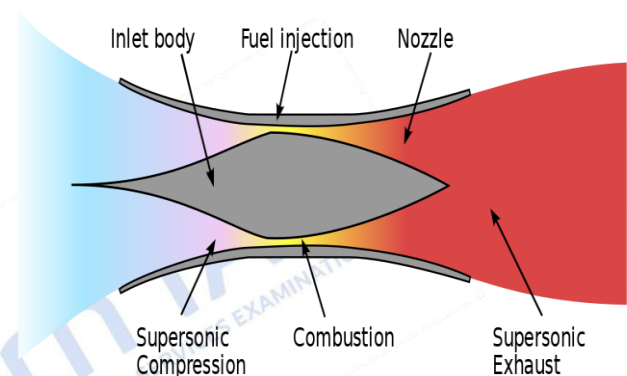
- ✓ Currently, three versions are offered as operational sounding rockets, which cover a payload range of 8-100 Kg and a range of 80-475 km.

SCRAMJET ENGINE – TECHNOLOGY DEMONSTRATOR

- ✓ **Air Breathing Propulsion System** has the potential to bring a significant shift in the launch vehicle design. The first experimental mission of ISRO's Scramjet Engine was successfully conducted on August 28, 2016.
- ✓ ISRO's Scramjet engine uses **Hydrogen as fuel** and **Oxygen from atmosphere as oxidiser**.
- ✓ **India is the fourth country** to demonstrate the flight testing of a Scramjet Engine.

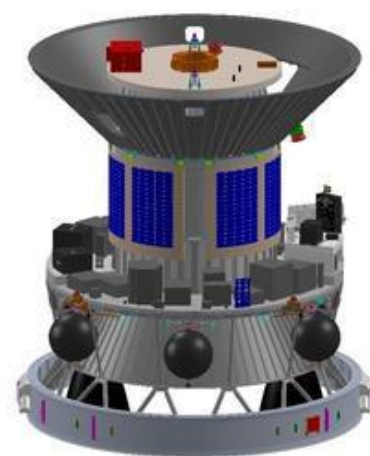
RAMJET AND SCRAMJET:

- ✓ Next generation launch vehicles are expected to have propulsion systems which can utilise the atmospheric oxygen during their flight.
- ✓ A **ramjet is a form of air-breathing jet engine** that uses the vehicles forward motion to compress incoming air for combustion without a rotating compressor. Fuel is injected in the combustion chamber where it mixes with the hot compressed air and ignites.
- ✓ A ramjet-powered vehicle **requires assisted take-off like a rocket** assist to accelerate it to a speed where it begins to produce thrust.
- ✓ Ramjets work most efficiently at **supersonic speeds around Mach 3**.
- ✓ A **Supersonic Combustion Ramjet, or Scramjet**, is an improvement over the ramjet engine as it efficiently **operates at hypersonic speeds** ($\text{Mach} \geq 5$). A Scramjet engine performs the **combustion itself at supersonic speeds** ($\text{Mach} \geq 1$).



PSLV ORBITAL EXPERIMENTAL MODULE (POEM)

- ✓ POEM is an experimental mission **which performs in-orbit scientific experiments during the fourth stage of the PSLV launch vehicle** as an orbital platform.
- ✓ The PSLV is a four-stage rocket where the first three spent stages fall back into the ocean, and **the final stage (PS4) — after launching the satellite into orbit — ends up as space junk**.
- ✓ However, in POEM mission, the **spent final stage will be utilised as a “stabilised platform”** to perform experiments.
- ✓ POEM has a **dedicated Navigation Guidance and Control (NGC) system** for attitude stabilization, controlling the orientation of any aerospace vehicle within permitted limits.



NEXT-GENERATION LAUNCH VEHICLE (NGLV)

- ✓ ISRO is developing a NGLV to **replace operational systems like the PSLV**.
- ✓ In NGLV, ISRO is looking at a cost-efficient, **three-stage to orbit, reusable heavy-lift vehicle** with a payload capability of ten tonnes to **Geostationary Transfer Orbit (GTO)**.
- ✓ It will feature **semi-cryogenic propulsion** (refined kerosene as fuel with liquid oxygen as oxidizer) for the booster stages. It will have 3 times the present payload capability with 1.5 times the cost of LVM3, resulting in **low-cost missions and modular propulsion systems**.
- ✓ This project will be **implemented with maximal participation from the Indian industry**, which is also expected to invest in the manufacturing capacity at the outset itself, thereby allowing a seamless transition to the operational phase subsequent to the development.
- ✓ NGLV will be demonstrated **with three development flights** (D1, D2 & D3) with a **target of 96 months** (8 years) for the completion of the development phase. It will enable national & commercial missions including launch of **human spaceflight missions to the planned Bharatiya Antariksh Station**.

