



MPPSC

Prelims

Madhya Pradesh Public Service Commission (MPPSC)

Volume - 6

Science, Technology & Environment



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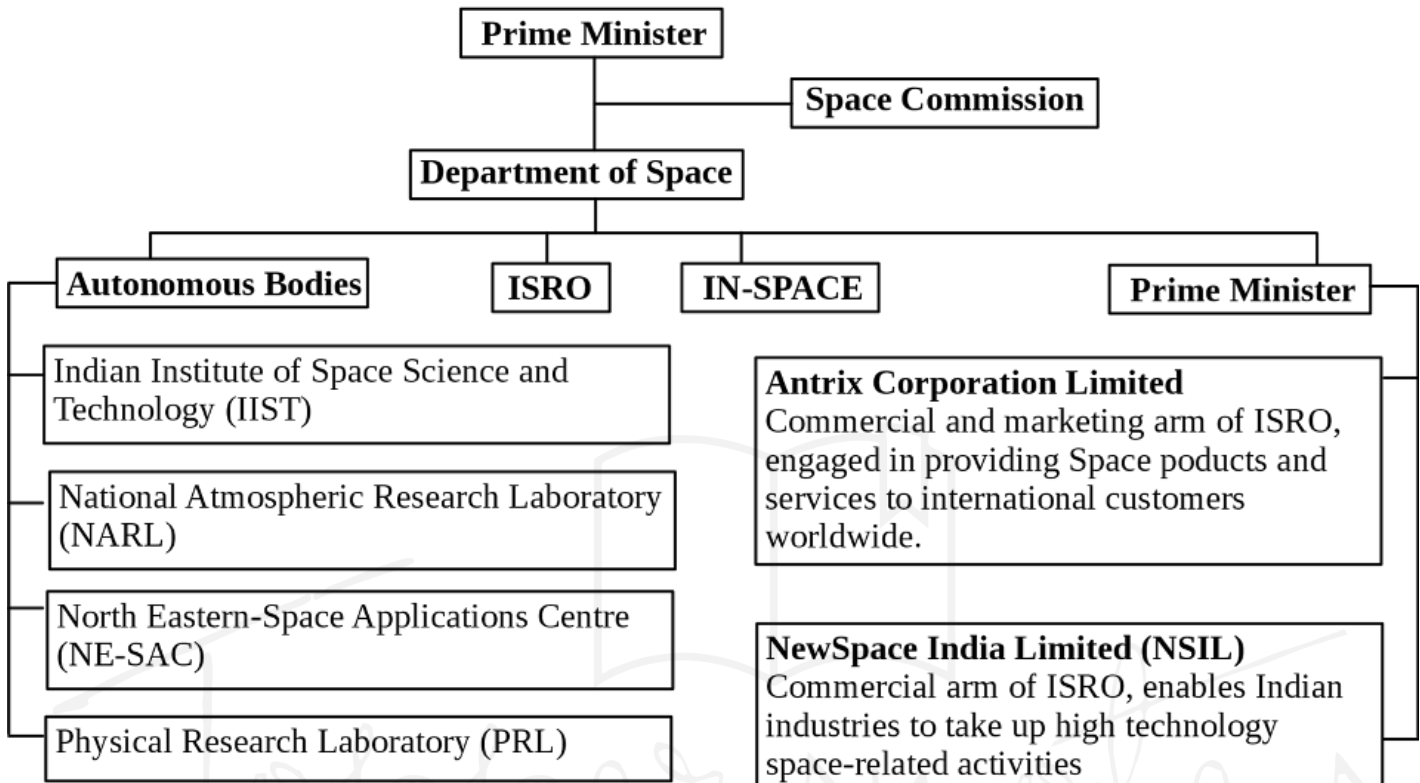
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CHAPTER

Space Technology

Overview of Organisation Structure



Space Organizations in India

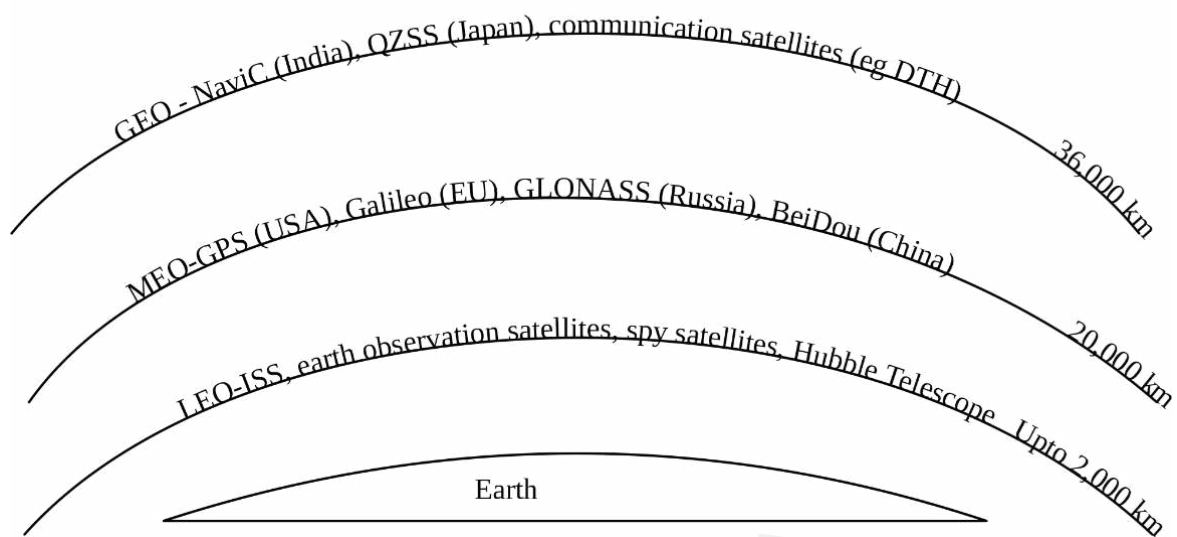
- 1. Indian Space Research Organization (ISRO)**
 - ✓ Nodal agency under the Department of Space, established 1969 and headquartered in Bengaluru.
 - ✓ Developed India's core launch vehicles: PSLV and GSLV.
- 2. Indian National Space Promotion and Authorization Centre (IN-SPACE)**
 - ✓ Created in 2020 to foster private-sector participation in space.
 - ✓ Facilitates partnerships between ISRO and industry for satellite fabrication, launch-vehicle development, and commercial launches.
- 3. New Space India Limited (NSIL)**
 - ✓ ISRO's wholly-owned commercial arm.
 - ✓ Enables industry consortia to undertake select ISRO projects and provides launch services, ground-station support, and data analytics.
- 4. Antrix Corporation**
 - ✓ ISRO's original commercial arm (founded 1992).
 - ✓ Markets space products, services, and technology transfers globally.

ORBITS

➤ Orbit is the curved path that an object (star, planet, spacecraft, moon) follows around another object due to the effect of gravity.

1. Types of Orbits: Based on Altitude

Orbits



2. Types of Orbits: Based on Function

Different Types of Orbits	
Geostationary orbit (GEO)	Satellites in GEO circle Earth above the equator from west to east following Earth's rotation. This makes satellites in GEO appear to be 'stationary' over a fixed position.
Low Earth orbit (LEO)	An orbit that is relatively close to Earth's surface. It is normally at an altitude of less than 1000 km but could be as low as 160 km above Earth.
Polar Orbit	Satellites in polar orbits usually travel past Earth from north to south rather than from west to east, passing roughly over Earth's poles.
Sun- synchronous orbit (SSO)	It is a particular kind of polar orbit. Satellites in SSO, travelling over the polar regions, are synchronous with the Sun.

Geo Synchronous	Sun synchronous
<ul style="list-style-type: none"> ➤ Satellite's revolutions is synchronised as per earth's Rotation. ➤ Orbits in equatorial plane ➤ Application: <ul style="list-style-type: none"> ✓ Communication ✓ Navigation 	<ul style="list-style-type: none"> ➤ Satellites revolution is synchronised on basis of Earth's Revolution. ➤ Orbits in Polar plane Application <ul style="list-style-type: none"> ✓ Earth Observation ✓ Remote sensing
<p>The diagram shows a large circle representing Earth with a smaller circle representing a satellite in a circular orbit around it. The orbit is in the equatorial plane, and the satellite is labeled 'Satellite'.</p>	<p>The diagram shows Earth with a satellite in an elliptical orbit that passes over the North and South poles. The orbit is labeled 'Polar Orbit' and the satellite is labeled 'Satellite'.</p>

Space Debris & Kessler Syndrome

- Space debris includes non-functional artificial objects, fragments, and components in Earth's orbit or re-entering Earth's atmosphere.
- **Kessler Syndrome:**
 - A phenomenon where the density of objects in Low Earth Orbit (LEO) increases, leading to collisions that generate more debris, triggering a chain reaction of further collisions.
 - India's Initiatives to counter Space Debris
 - Debris Free Space Missions (DFSM) 2030
 - Space Situational Awareness Control Centre (SSACC)
 - Project Network for Space Object Tracking and Analysis (NETRA)

➤ **Montreal Convention / UN Liability Convention (1972)** – A space-law treaty that makes any “launching state” absolutely liable for damage its space object causes on Earth (or to aircraft) and fault-based liable for harm in outer space, setting claims procedures and compensation rules.

Space Tourism

- Space tourism is a segment of space travel that enables individuals to visit space for recreational, leisure, or business purposes.
- Major players in space tourism include Blue Origin, Virgin Galactic, and SpaceX (Elon Musk's company).
- **Types:**
 - **Orbital Tourism:** Involves traveling to orbit around Earth.
 - **Suborbital Tourism:** Involves reaching the edge of space without completing an orbit.
 - **Lunar Tourism:** Involves traveling to the Moon.

	Suborbital tourism	Orbital tourism
Altitude	About 100 kilometres	Over 400 kilometres
Duration in Space	Gives passengers a few minutes in space	Spend days or even more than a week in space.
Velocity	Sub-Orbital <ul style="list-style-type: none"> ➤ Requires much lower speeds (than orbital) and doesn't have the power to achieve orbit. ➤ Instead, it will fly up to a certain height and then come back down once its engines are shut off. 	Orbital <ul style="list-style-type: none"> ➤ Spacecraft must achieve orbital velocity i.e. the speed that an object must maintain to remain in orbit around a planet.

DID YOU KNOW?

The **Kármán Line**, located at an altitude of 100 kilometers above Earth's sea level, is commonly used to define the boundary between Earth's atmosphere and outer space.



Van Allen Radiation Belt

- Earth's magnetosphere traps high-energy radiation particles, protecting the Earth from solar storms and solar winds that could damage technology and living beings.
- **Van Allen Belts:** These are two belts of radiation (inner and outer) surrounding Earth.
 - ✓ **Inner Belt:** Formed from interactions of cosmic rays with Earth's atmosphere.
 - ✓ **Outer Belt:** Composed of billions of high-energy particles from the Sun.

- Astronauts and spacecraft pass through these belts to reach space, and it is crucial to pass through quickly to minimize radiation exposure.
- Polaris Dawn Spacecraft has travelled through Earth's regions of high radiation that is the South Atlantic Anomaly and Van Allen Radiation Belt, to study space radiation's impact on human health.

DID YOU KNOW?



- South Atlantic Anomaly is the geographical region over the South Atlantic Ocean where the inner Van Allen radiation belt extends down close to Earth.
- **Polaris Dawn Mission:** 1st non-govt. Mission to conduct spacewalk, SpaceX will provide Falcon 9 and Dragon Capsule.

Launch Vehicles

- A launch vehicle is a rocket-powered system that carries a spacecraft beyond Earth's atmosphere into orbit or on interplanetary trajectories.
- **Major Components of the Launch Vehicles:** Engines, Fuel, Satellite / Payload, Command & Control System.

1. Engines

Engines Types	
Non air breathing propulsion system	Air breathing population system (Ramjet/Scramjet)
Use of Oxidiser to burn fuel that is kept on the rocket	Air breathing: word breakdown
Oxidiser adds to mass of rocket	Oxygen from air to burn fuel
Heavier	Lighter

- A **jet engine** is a type of reaction engine that generates thrust through jet propulsion by discharging a fast-moving jet.
- Although the term can include rocket, water jet, and hybrid propulsion, it typically refers to **internal combustion airbreathing jet engines** like turbojet, turbofan, ramjet, or pulse jet.
- Generally, jet engines are internal combustion engines.
- The major jet engines includes:

Ramjet	Scramjet (Supersonic combustion ramjet)	Dual Mode Ramjet (DMRJ)
<ul style="list-style-type: none"> ➤ Uses vehicle's forward motion to compress incoming air for combustion without a rotating compressor. ➤ Work at supersonic speeds around Mach 3 (three times the speed of sound) and can operate up to speeds of Mach 6 	<ul style="list-style-type: none"> ➤ Efficiently operates at hypersonic speeds and allows supersonic combustion. ➤ Uses Hydrogen as fuel and the atmospheric oxygen from the atmospheric air as the oxidiser. ➤ Both ramjets and scramjets have no moving parts. ➤ A scramjet (supersonic combustion ramjet) is a variant of a ramjet that burns fuel in supersonic airflow. 	<ul style="list-style-type: none"> ➤ When a ramjet transforms into scramjet over Mach 4-8 range. ➤ Operate both in subsonic and supersonic combustor modes.

<ul style="list-style-type: none"> ➤ Efficiency starts to drop at hypersonic speeds. ➤ Does not have any turbines unlike the turbojet engines (jet engines). ➤ A ramjet is an airbreathing jet engine that generates thrust from its forward motion. 	<ul style="list-style-type: none"> ➤ Like a ramjet, a scramjet uses high vehicle speed to compress incoming air, but instead of a shock cone, it uses shockwaves produced by its ignition source to slow the airflow. ➤ This enables the scramjet to operate efficiently at extremely high speeds, unlike ramjets that decelerate air to subsonic speeds using shock cones. 	
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Mach Number	
➤ Subsonic	Mach < 1.0
➤ Transonic	Mach = 1.0
➤ Supersonic	Mach > 1.0
➤ Hypersonic	Mach > 5.0

<p>Cryogenic Engine</p> <ul style="list-style-type: none"> ➤ It is indigenously developed by India. It stores fuel (liquid hydrogen) and oxidizer (liquid oxygen) at very low temperatures and is used in the last stage of a rocket. ➤ Oxygen and Hydrogen provide best thrust with highest efficiency and emit only steam.

Comparison of Cryogenic Engine with other engines

Characteristics	Cryogenic Engine	Jet Engine	Solid Propellant Engine	Liquid Propellant Engine
Air Intake	No air intake is required.	Air intake is required.	Air intake is required as oxidizer. 1	Air intake is required as oxidizer.
Fuels	Generally super cooled Hydrogen and Oxygen.	(Jet A-1, Kerosene-gasoline mixture, Aviation gasoline (avgas), Bio-kerosene.	Fuels for composite propellants are generally metallic powders, with aluminium being the most common.	Hydrazine, monomethyl hydrazine (MMH), unsymmetrical dimethyl hydrazine (UDMH) etc.
Fuel temperature,	Temperature of fuel, must be Very low.	Fuel storage does not require low temperature.	Fuel storage does not require low temperature.	Fuel storage does not require low temperature.
Efficient working	It runs efficiently when low temperature fuel transforms and mixes correctly and ignites.	It runs efficiently at supersonic speed that forcefully compresses air before combustion.	It runs efficiently when fuel is provided with sufficient oxidizer.	It runs efficiently when fuel is provided with sufficient oxidizer.
Purpose	Third stage/ last stage of rocket.	Used in the Airplanes etc.	Used as boosters in initial liftoff.	Act as main stage of rocket after booster separation.

2. FUELS

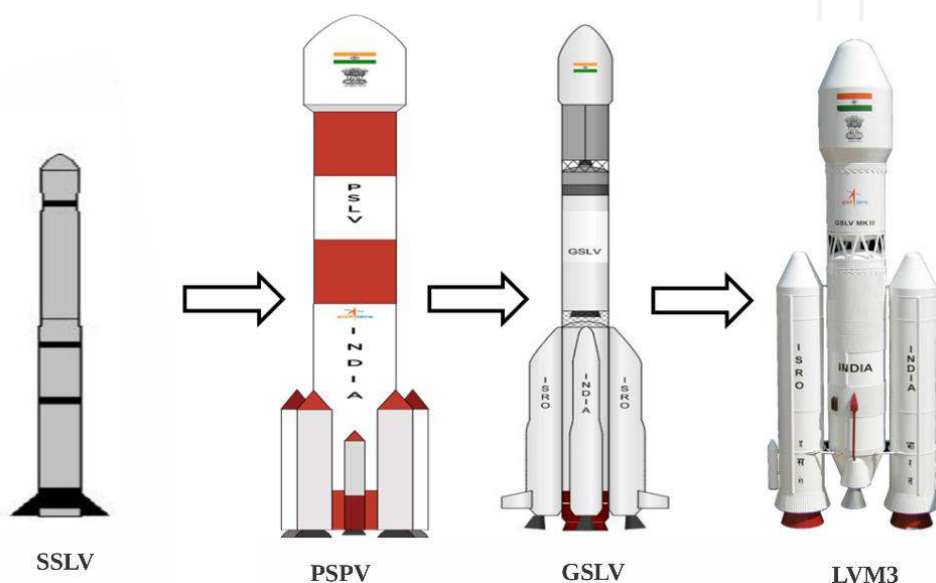
Type	Advantage	Disadvantage
Solid	<ul style="list-style-type: none"> ➤ Easy Storage and Transfer ➤ All rockets use solid fuel in 1st stage as it gives more energy 	<ul style="list-style-type: none"> ➤ Heavy weight ➤ Non-uniform burning
Liquid	<ul style="list-style-type: none"> ➤ Higher efficiency and uniform burning ➤ Less weight 	<ul style="list-style-type: none"> ➤ Difficulty in storage and transport.

Domain	Solid fuel technology	Liquid fuel technology
Fuel and Oxidiser	<ul style="list-style-type: none"> ➤ Solid propellants are a mixture of fuel and oxidiser. ➤ Fuel-Metallic powders(aluminium) ➤ Oxidiser: Ammonium nitrate, Potassium chlorate. 	<ul style="list-style-type: none"> ➤ Liquid-fuel rockets consist of a fuel and oxygen (or other oxidizer) in liquid state. ➤ Fuel: kerosene, alcohol, hydrazine and its derivatives, and liquid hydrogen ➤ Oxidiser: Nitric acid, nitrogen tetroxide, liquid oxygen, and liquid fluorine
Mechanism	<ul style="list-style-type: none"> ➤ The fuel and oxidiser are bound together by a hard rubbery material and packed into a metal casing. 	<ul style="list-style-type: none"> ➤ They are combined in a combustion chamber and ignited.
Advantages	<ul style="list-style-type: none"> ➤ Minimum maintenance and instant readiness, fuel can be stored for longer time. 	<ul style="list-style-type: none"> ➤ Fuel flow can be regulated and the engine can be turned off, provides greater thrust and power.
Disadvantages	<ul style="list-style-type: none"> ➤ Resulting thrust cannot be regulated or turned off. 	<ul style="list-style-type: none"> ➤ Separate storage for fuel and oxidant, complex technology, increased weigh etc.

Helium as a fuel in rocket- colorless, odorless, non-toxic and the Universe's No. 2 element (forged via stellar fusion).

- It isn't burned in rockets but serves as an inert, super-cold gas to pressurize propellant tanks and purge lines, letting engines fire safely and reliably.

3. Launch Vehicles types: SSLV v/s PSLV v/s GSLV



ISRO's Launch Vehicles		
Launch Vehicle	Stages	Payload capacity and Orbits
Small Satellite Launch Vehicle (SSLV)	3 stage Launch Vehicle (Three Solid Propulsion Stages and liquid propulsion-based Velocity Trimming Module as a terminal stage.)	Mini, Micro, or Nanosatellites (10 to 500 kg mass) to a 500 km orbit.
Polar Launch Vehicle (PSLV)	Four-stage launch vehicle (1st & 3rd stage: Solid; 2nd & 4th: Liquid)	Up to 1,750 kg to Sun-Synchronous Polar Orbits, 1,425 into Geosynchronous and Geostationary orbits
Geosynchronous Satellite Launch Vehicle (GSLV) Mark II	Three-stage launch vehicle (1st: Solid, 2nd: Liquid; 3rd: Cryogenic Upper Stage)	Up to 2,250 into Geosynchronous Transfer Orbits, up to 6 tonne in Low Earth Orbits
Geosynchronous Satellite Launch Vehicle Mk-III (LVM3)	Three-stage launch vehicle (1st: Liquid, 2nd: Solid; 3rd: Cryogenic Upper Stage)	Up to 4 tonne into Geosynchronous Transfer Orbits, 8 tonne into Low Earth Orbits

Next Generation Launch Vehicles (NGLV)

- The NGLV programme aims to develop the Soorya Rocket, a new launch vehicle for satellites and spacecraft.
- **Features:** 3-stage vehicle with a reusable first stage, Semi-cryogenic propulsion for booster stages, Payload capacity is three times greater than the current LVM3, with 1.5 times the cost efficiency.

➤ KALAM - 250

- ✓ Skyroot Aerospace has successfully test-fired Stage-2 of its Vikram-1 space launch vehicle, named Kalam-250 (Vikram-1 is a three-stage, solid-fuel rocket).
- ✓ This stage is crucial for propelling satellites from Earth's dense atmosphere into the vacuum of space.
- ✓ Kalam 250 has a high-strength carbon composite rocket motor and uses solid propellant.

Sounding Rockets

- Sounding rockets are short-range vehicles propelled by solid fuel that carry scientific instruments into the upper atmosphere for in-situ measurements.
- India's first sounding rocket, the RH-500, launched from the Thumba Range in 1963, marking the nation's entry into space research.
- **RH-560:** Sounding Rocket, two-staged solid, used as cost-effective flying test bed for demonstrating advanced propulsion technologies, heaviest rocket in ISRO's fleet.

- **Reusable Launch Vehicle Technology:** It aims to develop essential technologies for a fully reusable launch vehicle to enable low-cost access to space. ISRO's RLV Landing Experiment (LEX):
 - ✓ The mission simulated **high-speed landing conditions** for a vehicle returning from space.
 - ✓ The test was conducted using a **winged vehicle** named '**Pushpak**'.
 - ✓ Unlike **SpaceX's Falcon 9**, which lands vertically, **Pushpak** uses wings for **horizontal gliding** to land.

AVATAR (Aerobic Vehicle for Trans atmospheric Hypersonic Aerospace Transportation)

- It is ISRO's planned reusable launch vehicle platform which will carry out satellite launches like normal aircraft, take off vertically and land back on a runway. It is designed to use ramjets and scramjets for thrust.

➤ **RHUMI-1**

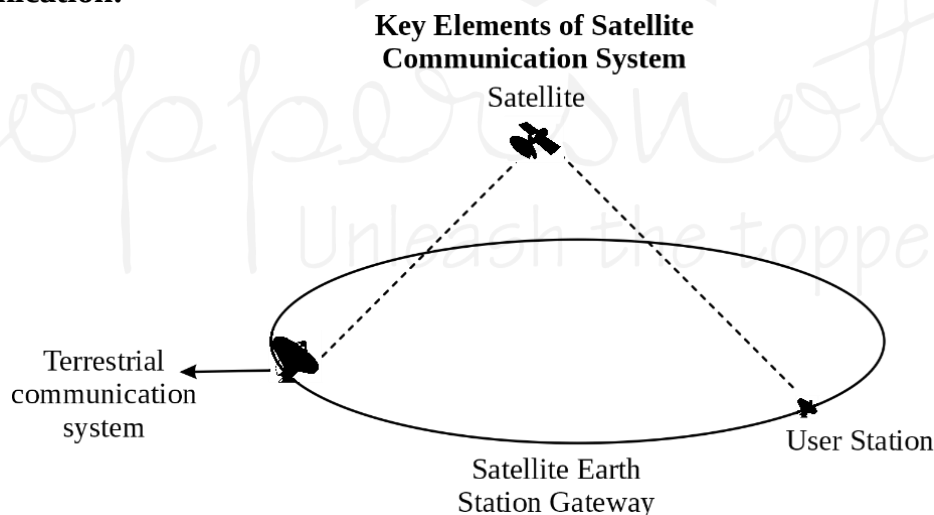
- ✓ It is India's first Reusable Hybrid Rocket developed by Tamil Nadu based startup Space Zone India.
- ✓ Reusable rockets release the payload, land back on Earth, and again be launched with a new payload.
- ✓ It uses a combination of solid and liquid propellants to improve efficiency and reduce operational costs.

➤ **About Small Satellite Launch Vehicle (SSLV)-D3**

- ✓ It is the third developmental flight of SSLV.
- ✓ It is capable of launching Mini, Micro or Nano satellites (10 to 500 kg mass) into 500km planar orbit.
- ✓ It uses three solid fuel-based stages and a final liquid-fuel based stage.
- ✓ Benefits: Low cost, low turn-around time, minimal launch infrastructure requirements, etc.

SATELLITES

- Satellites are the celestial bodies orbiting larger objects (e.g., planets).
 - ✓ It can be natural (e.g., Earth's Moon) or artificial, launched by rockets into prescribed orbits.
 - ✓ An artificial satellite remains in orbit due to Earth's gravity providing the centripetal acceleration required for its motion.
- The primary function of the satellite includes:
 - ✓ **Earth Observation:** Monitoring atmosphere, land, oceans, vegetation health, greenhouse-gas emissions, surface temperatures around Earth.
 - ✓ **Navigation:** Providing positioning and timing services for civilian and military users.
 - ✓ **Communication:**



- ✓ Broadcasting, telephony, internet connectivity across vast regions.

Navigation with Indian Constellation (NAVIC)

- It is a regional navigation satellite system (earlier known as Indian Regional Navigation Satellite System) launched by ISRO.
- **Key Navigation Satellite System**
 - ✓ GPS (Global Positioning System) - United States
 - ✓ -GLONASS (Global Navigation Satellite System) - Russia
 - ✓ Galileo - European Union

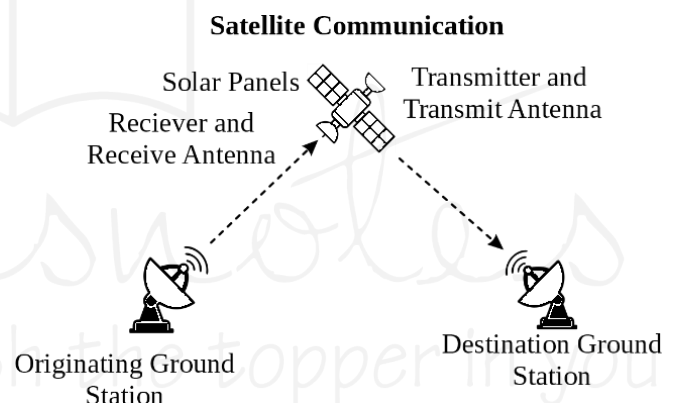
- ✓ BeiDou China
- ✓ QZSS (Quasi-Zenith Satellite System) - Japan
- It consists of 7 satellites of which 3 satellites are placed in geostationary orbit and 4 satellites are placed in geosynchronous orbit.
- Advantage of NavIC over GPS
 - ✓ Provides better positioning accuracy of 10 meters compared to GPS' accuracy of 20 meters.
 - ✓ Unlike GPS, NavIC satellites are much above the Earth's surface, hence, lesser signal blockages in Himalayan mountains or on terrestrial surfaces.
- Its coverage includes India and region upto 1500 Km beyond Indian boundary.

GPS Aided GEO Augmented Navigation (GAGAN)

- A regional Satellite Based Augmentation System (SBAS), a collaboration of Airports Authority of India and ISRO.
- The main goal is to provide a navigation system to assist aircraft in accurate landing over the Indian airspace and in the adjoining area.
- India is the third country in the world which has such precision approach capabilities.
- **GEMINI-(GAGAN Enabled Mariner's Instrument for Navigation and Information.)**
 - ✓ It uses the GAGAN system (developed by ISRO and Airport Authority of India).
 - ✓ It will alert deep-sea fishermen about upcoming disasters (high wind, rough sea, cyclone, tsunami, etc.) and potential fishing zones.
 - ✓ It is one-way communication (like FM radio).

1. SATELLITE INTERNET

- ✓ It is a wireless internet through communication satellites orbiting the Earth.
- ✓ Satellites communicate with each other using lasers, reducing dependence on ground stations.
- ✓ It is suited for unconnected areas, connectivity during disasters, provides connectivity between military bases and military planes, ships, drones etc.
- ✓ Disadvantages: High Latency, Atmospheric changes, technical limitations, etc.



DID YOU KNOW?

- Satellite Constellation is a network of identical artificial satellites with the same purpose and shared control, designed to work as a system.
- **ZigBee:** high level communication protocols using low power digital radios.



2. GSAT 7 SERIES SATELLITES

- ✓ **GSAT 7:** Launched in 2013, this satellite is primarily used by the Indian Navy for secure, real-time communication.
- ✓ **GSAT 7A:** Launched in 2018, it enhances connectivity between ground radar stations, air bases, and airborne early warning and control aircraft (AEW&C) of the Indian Air Force.
- ✓ **GSAT 7B:** Set to address the Indian Army's communication needs, it will bolster surveillance in border areas.

3. **Operation Skylight** (Indian Army, 2023)- was a nationwide drill that linked hundreds of field formations through the force's dedicated GSAT-series satcom network.
- ✓ It stress-tested secure, high-bandwidth links and backup nodes, proving the Army's ability to maintain assured C4ISR communications in combat or disaster scenarios.

Telescopes

1. Major Atmospheric Cherenkov Experiment

- ✓ It is the largest imaging Cherenkov telescope in Asia and 2nd largest in the world.
- ✓ It is indigenously built by Bhabha Atomic Research Centre (BARC).
- ✓ Its objective is to observe high-energy gamma rays to understand the most energetic phenomena in the universe.

2. Square Kilometre Array

- ✓ It is the world's largest radio telescope consisting of one global observatory, operating two large telescopes (South Africa and Australia).
- ✓ Its objective is to understand the birth of the Universe, detect gravitational waves, evolution of galaxies, etc.
- ✓ India has been an associate member since 2012.

3. **TAO Telescope (Chile)** – a 6.5 m optical-IR telescope atop Chile's (5,640 m Cerro Chajnantor), the world's highest; leverages the Atacama's bone-dry air for pristine skies. It will dissect newborn galaxies, star-forming clouds, and exoplanet atmospheres at wavelengths that elude lower observatories.

4. **KM3NeT (Mediterranean Sea)** – a cubic-kilometre neutrino observatory anchored deep off France and Italy, detects the Cherenkov flashes sparked by cosmic neutrinos in Mediterranean waters. By retracing these tracks it pinpoints extreme astrophysical sources and sharpens neutrino-mass and oscillation measurements, complementing Antarctica's IceCube.

5. James Webb Space Telescope (JWST)

- ✓ It is the successor of the Hubble Space Telescope launched in 2021 by NASA, European Space Agency (ESA) and the Canadian Space Agency (CSA).
- ✓ **Objective**

Early Universe	Exoplanets	Outer Planets	Small Worlds
JWST will allow us to see galaxies that formed just 100 million years after Big Bang	JWST will scan atmospheres of earth-like exoplanets, searching for gases associated with life	Will monitor Jupiter, Saturn, Uranus, and Neptune to see how their atmospheres change over time.	From the asteroid belt to Kuiper belt, JWST will determine what makes up some of our solar system's smallest objects

DID YOU KNOW?

The expansion of the Universe is calculated by the Hubble constant.



6. Astrosat

- ✓ It was launched by ISRO in 2015 and is India's first dedicated multi-wavelength space observatory.
- ✓ It aims to study celestial sources in X-ray, optical, and UV spectral bands simultaneously.

Isro's Space Missions

1. **ARYABHATA:** was India's first satellite built by ISRO and launched by the USSR in 1975.
 2. **SPACE DOCKING EXPERIMENT (SPADEX)**
 - ✓ India becomes the 4th country to successfully conduct space docking after the USA, Russia and China.
 - ✓ Space Docking involves precise connection of two spacecraft, whether manned or unmanned, allowing those to operate as a single unit for critical tasks such as refuelling, repair and crew exchange.
 - ✓ **ISRO's SPADEX** is a technology demonstration experiment focused on mastering **autonomous docking**, a critical capability held by only a few countries (the US, Russia, and China).
 - ✓ It consists of two satellites, '**Chaser**' and '**Target**', which will dock at an altitude of approximately **700 km**.
 3. **BHARATIYA ANTARIKSH STATION (BAS)**
 - ✓ **BAS** is India's planned space station for scientific research, set to orbit at an altitude of **400-450 km** above Earth's surface.
 - ✓ It will consist of **five modules** and will be constructed in phases.
 - ✓ The **first module** (Base Module) is expected to be launched in **2028**, with the station becoming fully operational by **2035**.
 - ✓ **Significance of BAS**
 - Serves as a testing ground for studying how to keep astronauts safe and healthy on long-duration missions.
 - Earth observation Provides better spatial resolution and variable lighting conditions.
 - Microgravity research, for example, muscles and bones react differently in space than on Earth.
- **Other Space Station**
- ✓ **Inoperative:**
 - **Salyut 1:** World's 1st space station launched by USSR.
 - **Skylab:** USA's 1st space station.
 - ✓ **Operative:**
 - International Space Station:
- **Key Facts about ISS**
- ✓ Travels at a speed of 5 miles/second, orbiting Earth about every 90 minutes.
 - ✓ Weighs almost 400 tonnes.
 - ✓ Covers an area as big as a football pitch.
 - ✓ Largest artificial body in orbit.
 - ✓ Has been continuously inhabited for more than 20 years beginning with Expedition 1 in 2000.
 - ✓ Orbital inclination is 51.6°, permitting it to fly over 90% of inhabited Earth.
 - ✓ It has been operational since 2000 and maintained in low Earth Orbit (LEO) by collaboration of 5 space agencies - NASA (USA), Roscosmos (Russia), ESA (EU), JAXA (Japan) & CSA (Canada).
 - ✓ **Tiangong:** launched by China in 2021.
 - ✓ **Upcoming Space Stations**
 - ✓ **Gateway Space Station:** Humanity's first space station around the moon by NASA.
 - ✓ **Axiom Station:** It is the world's first commercial space station being developed by Axiom Space to operate in LEO.

4. VENUS ORBITER MISSION (ISRO'S SHUKRAYAAN)

- ✓ The objectives of the mission include examining dust in the Venus atmosphere, mapping of topography, study of solar X-ray spectrum and investigating sub-surface characteristics.
- ✓ The mission will be launched by 2028 and will be launched through Launch Vehicle Mark 3.

DID YOU KNOW?

- Venus is considered as 'Earth's-twin' and is the hottest planet in our solar system.
- Venus, along with Uranus, rotates from east to west, while all other planets rotate west to east.



Gaganyaan Mission

- India's first **Human Space Flight** mission, aimed at transporting astronauts to an orbit **400 km above Earth** for a **three-day expedition**, followed by a safe return.
- The mission will also carry a **female half-humanoid, Vyomitra** (space friend).
- **Human-rated LVM3 (HLVM3)**: A reconfigured version of the **LVM3** rocket, featuring solid, liquid, and cryogenic stages, specifically designed to meet human-rating requirements for crew safety.
- The successful launch of **Gaganyaan** will make India the **4th country** (after the US, Russia, and China) to successfully launch a crewed spacecraft.

5. ADITYA L1

- ✓ It is India's first space mission to study the Solar upper atmospheric (Corona) dynamics.
- ✓ Corona is responsible for initiation of the coronal mass ejection (CMEs) and solar flares.

Lagrange point

- It is the point where the gravitational pull of the two large bodies equals the necessary centripetal force required for a small object to move with them.
- There are a total 5 lagrange points out of which L4 and L5 are in the stable zone.
- **Significance:** Spacecraft remain at these positions with reduced fuel consumption.

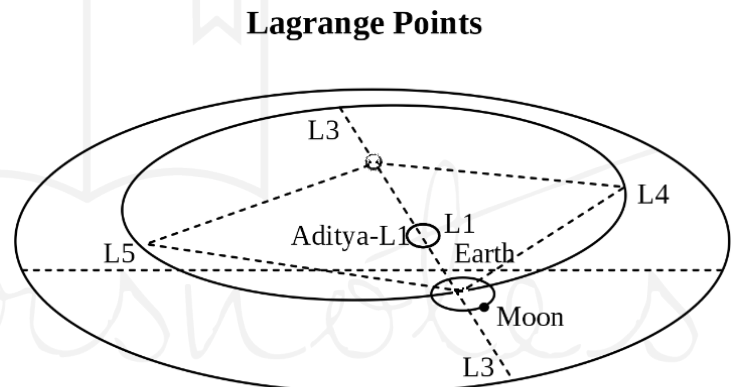


Illustration of all five Lagrange points of Sun- Earth system. Aditya-L1 will be placed around Lagrange point 1

➤ Other Missions to Sun

- ✓ **Parker Solar Probe (NASA)**: The first human-made object to fly close to the Sun, traveling at approximately 700,000 kilometers per hour, making it the fastest human-made object in history.

DID YOU KNOW?

Halo Orbits are periodic, three-dimensional orbits created by the interaction between the gravitational pull of two planetary bodies and the centrifugal force on a spacecraft. These are mainly associated with the L1, L2 and L3 points.



6. Mars Orbiter Mission (MOM)

- ✓ India's first interplanetary spacecraft, also called **Mangalyaan**, launched by ISRO on 5 November 2013 to demonstrate India's capability in deep-space missions.
- ✓ **Objectives:** Study Martian surface features, morphology and mineralogy, measure Martian atmosphere's composition and dynamics and to Investigate the presence of methane and other trace gases.
- ✓ **Launch Vehicle:** PSLV-XL (PSLV-C25) from Satish Dhawan Space Centre.

7. CHANDRAYAAN - 3

- ✓ India's **Chandrayaan-3** mission successfully achieved a **soft landing** of the **Vikram Lander** on the **lunar surface** on **August 23, 2023** (National Space Day).
- ✓ A follow-up to **Chandrayaan-2 (2019)**, it became the first mission to soft-land near the **lunar South Pole** (Far side) at the '**Shiv Shakti**' point.
- ✓ **Pragyan Rover** was deployed after the successful landing.
- ✓ India became the **4th country** (after the US, Russia, and China) to soft-land on the Moon.
- ✓ **Launch Vehicle:** Geosynchronous Satellite Launch Vehicle Mk III.
- ✓ **Key Payloads:** Chandra's Surface Thermophysical Experiment (ChaSTE), Alpha Particle X-ray Spectrometer (APXS).

CHANG'E 6

China has successfully launched the Chang'e-6 lunar probe, weighing over 8 metric tons. This mission aims to bring back 2 kilograms of samples from the far side of the Moon, a feat never before accomplished by humans.

DID YOU KNOW?



- The far side of the Moon refers to the hemisphere of the Moon that always faces away from Earth.
- This is due to the Moon being tidally locked with Earth due to gravitational pull.
- It has thicker dust, more craters and fewer lava plains due to being unexposed to the Sun

8. CHANDRAYAAN 4

- ✓ It aims to develop and demonstrate key technologies for **Moon landing, lunar sample collection, and safe return to Earth.**
- ✓ This mission will lay the **foundational technologies** for a future **Indian Moon landing** (planned by **2040**) and safe return to Earth.

9. LUPEX MISSION

- ✓ It is a collaboration between ISRO and JAXA.
- ✓ It aims to investigate the quantity and quality of water on the Moon, particularly exploring the **lunar South Pole**, believed to have high water potential.

10. NISAR (NASA - ISRO Synthetic Aperture Radar)

- ✓ It is an Earth observatory satellite in Sun-synchronous orbit (LEO) launched in 2024 through GSLV Mk II.
- ✓ Its objectives are to study surface changes, monitor natural hazards, analyze climate patterns, and enhance our understanding of Earth's dynamic ecosystems from space, surveying the planet's land and ice every 12 days over its three-year mission life.

SCOT-(Mission Space Camera for Object Tracking)

- SCOT is Digantara's (an Indian space startup) inaugural mission dedicated to space surveillance.
- It is one of the world's first commercial Space Situational Awareness satellites.
- It was launched aboard SpaceX's Transporter-12 mission.
- SCOT is built to track Resident Space Objects (RSOs).

11. TRISHNA - a late-2020s ISRO&CNES mission, will fly a thermal-IR imager in Sun-synchronous orbit to map land-surface temperature, evapotranspiration, and soil-moisture.

- ✓ Its data will close the energy- and water-budget gap for continental ecosystems, aiding drought, irrigation, and climate-impact monitoring.

12. PROBA-3 MISSION: It is the world's first precision formation flying mission.

- ✓ Mission of European Union and will be launched by ISRO.
- ✓ It will mimic an artificial eclipse in space, providing a continuous view of the corona.

13. XPOSAT

- ✓ First dedicated satellite from ISRO to carry out research and measure X-ray emission from celestial sources like black holes and neutron stars.
- ✓ Second satellite in the world to study X-ray polarization, first being NASA's Imaging X-ray Polarimetry Explorer (IXPE).

ISRO successfully launched the X-ray Polarimeter Satellite (XPoSat) by Polar Satellite Launch Vehicle (PSLV) -C58.

➤ **Significance of the Mission**

- ✓ Understanding the nature of radiations: Polarization measurements lead to better understanding of the emission processes from astronomical sources.
- ✓ Advanced data collection: Polarization study of celestial sources was done either in the optical or radio bands before. X-ray polarimetry in the medium energy band is being done for the first time.
- ✓ Other: Chemical Composition of celestial bodies like Pulsars, Magnetars etc., Better understanding of Universe etc.

14. Analog Space Mission

- ✓ Analog space missions are field tests done in locations that have physical similarities to that of the extreme space environments.
- ✓ Developed by joint collaboration of ISRO's Human Spaceflight Center, and other partners.
- ✓ Other major analog missions: NEEMO (NASA), SIRIUS Program (UAE), etc.

ISRO has launched India's first analog space mission in Leh (Ladakh) to plan lunar mission experiments.

Ladakh as Astronomical Hub of India

- Indian Astronomical Observatory (IAO): Located in Hanle, Ladakh, with an optical infrared telescope.
- Astro Tourism: E.g. Hanley Dark Sky Reserve (HDSR).
- Host to various Space Programmes: NASA's Spaceward Bound India Programme 2016, Field validations of ExoMars 2020 HABIT Instrument etc.

Important Space Missions

- 1. JUNO MISSION:** launched by NASA in 2011 to understand the origin and evolution of Jupiter.
- 2. PACE Mission:** NASA's PACE satellite (2024) uses a hyperspectral Ocean Color Instrument and polarimeters to map global plankton, aerosols, and clouds each day.
 - ✓ These data reveal where the ocean absorbs or emits CO₂, letting scientists refine carbon-cycle and climate projections.
- 3. MAVEN Mission:** NASA's MAVEN orbiter (Mars Atmosphere and Volatile Evolution, 2014-present) samples the upper Martian atmosphere and solar wind to measure how particles and gases escape to space

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4. **Europa Clipper:** NASA's largest-ever planetary spacecraft launched in 2024 to make ~50 close fly-bys of Jupiter's icy moon Europa, giving the first thorough habitability assessment of Europa.
 5. **Earth CARE Mission:** The Earth CARE (Earth Cloud Aerosol and Radiation Explorer) mission is a joint initiative by the ESA and JAXA designed to study the complex interactions between clouds, aerosols, and radiation in the Earth's atmosphere. This mission is crucial for improving our understanding of Earth's climate and enhancing the accuracy of climate models.
 6. **RISE Mission:** ESA's RISE (Responsive In-orbit Servicing & Assembly) craft, due late-2020s, will dock with satellites to refuel, repair, and help build larger structures in space. The tech-demo aims to extend mission lifetimes and slash orbital debris, paving the way for a sustainable on-orbit economy.
 7. **Parker Solar Probe:** NASA's Parker Solar Probe (2018) swoops to within ~6 million km of the Sun, directly sampling coronal plasma, fields, and particles. Its data explain how the corona heats and propels the solar wind, sharpening space-weather forecasts for Earth.
 8. **LIGNOSAT:** JAXA's Ligno Sat (launch planned 2024-25) will be the world's first wooden satellite, its magnolia panels exposed to vacuum, radiation, and rapid temperature shifts. Data on wood's durability could enable eco-friendly, easily disposable satellite structures that cut orbital debris.
 9. **DRAGONFLY MISSION:** NASA's Dragonfly mission to Titan, Saturn's largest moon, is set to launch in 2028 as part of NASA's New Frontiers Program, which also includes missions like New Horizons, Juno, and OSIRIS-REx.
 - ✓ The mission aims to explore Titan's chemistry and potential habitability by studying multiple surface sites across a large area.
 - ✓ Titan is the only known moon in our solar system with a thick atmosphere and liquid seas on its surface, making it a key target for exploring extraterrestrial habitability.
 10. **VOYAGER 1:** launched in 1977 by NASA to flyby Jupiter and Saturn and it crossed into interstellar space in 2012.
 - ✓ It was the first spacecraft to cross the heliosphere.
 11. **JUICE MISSION:** launched by European Space Agency (ESA) to study Jupiter and its three large ocean-bearing moons- Ganymede, Callisto and Europa.
 - ✓ Observe moons weather, magnetic field, gravitational pulls, etc.
 12. **Compact Research Module for Orbital Plant Studies (CROPS):** 1st biological experiment to grow plants in space under microgravity, successfully germinated cowpea seeds in just 4 days in space.
- **Starship:** SpaceX's two-stage Starship system pairs the Super Heavy booster with the Starship spacecraft to create a fully reusable super-heavy launcher for crew and cargo missions to Earth orbit, the Moon, and Mars. By re-flying both stages, it targets unrivalled payload capacity at aircraft-like cost per flight.
 - **Falcon 9:** SpaceX's partially reusable Falcon 9 re-lands its first stage after lofting satellites, Dragon-2 crew capsules, and Starlink batches on a versatile two-stage stack. Routine booster reuse has slashed launch prices and ushered in the era of commercial human spaceflight.
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