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# G.K. & CURRENT AFFAIRS

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# Countdown to Axiom-4 India's Historic Leap in Space

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# Why in News?

### First Indian on ISS

**Shubhamshu Shukla**, an Indian pilot, is set to fly aboard the **Axiom-4 Mission** to the **International Space Station (ISS)** on **June 8, 2025**.

### Historic Milestone

He will be the **first Indian to step on the ISS**, marking a milestone for India in international human spaceflight.

### Strategic Cooperation

Though the Indian Space Research Organisation (ISRO) is not directly involved, this mission reflects strategic Indo-US space cooperation and prepares ground for India's own **Gaganyaan mission**.

# About the AXIOM-4 Mission

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| Feature | Details |
| --- | --- |
| **Launch Date** | June 8, 2025 |
| **Launch Site** | Kennedy Space Centre, Florida |
| **Spacecraft** | SpaceX Dragon |
| **Crew Members** | Peggy Whitson (US, Commander), Shubhamshu Shukla (India, Pilot), Slawosz Uznanski (Poland), Tibor Kapu (Hungary) |
| **Organized by** | Axiom Space (private US space firm) |
| **Support** | NASA, SpaceX |

# Key Experiments on Board

### Cognitive & Neural Impacts

Study how space affects **cognitive response**, especially facial emotion recognition and gaze fixation.

### Tardigrade Behaviour

Analyze **tardigrade survival** and behaviour in extreme space conditions.

### Crop Studies

Impact of microgravity on **six types of crops** to enhance food sustainability.

### Cyanobacteria Research

Study growth and **cellular response of cyanobacteria**, crucial for **life support systems** in space.

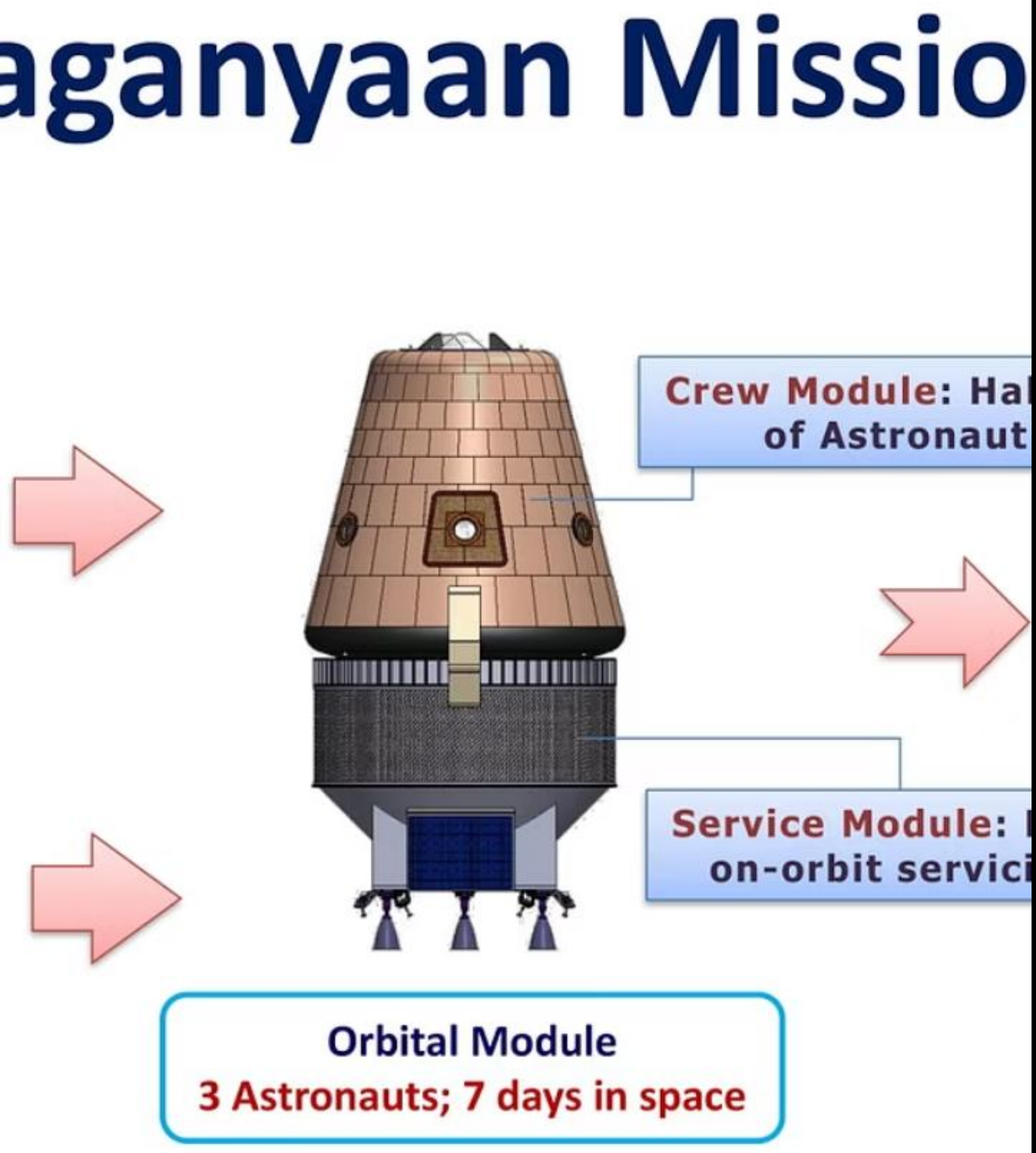
# India's Role & Strategic Importance


## Precursor to Gaganyaan

Though India has **no direct operational role**, this mission is a **precursor** to India's **Gaganyaan**—its first manned space mission, now likely in **2027**.

## Strategic Cooperation

NASA and ISRO agreed in 2023 to **strategic human spaceflight cooperation**, enabling Indian presence on Axiom-4.




# Connection to Gaganyaan

## Experiential Feedback

Shukla's role in Axiom-4 will offer **critical experiential feedback** for India's upcoming Gaganyaan crew.

## Space Experiments

ISRO has planned **10 space experiments**, including:

- **Microgravity effects** on muscles and the nervous system.
- **Plant growth studies** in space.

## Future Implementation

These experiments will later be implemented in Gaganyaan.

# Significance of Shubhamshu Shukla's Role

## Pilot of Axiom-4

Shukla brings back **SpaceX crew training experience** to Indian missions.

## "Testbed" for India

His journey is considered a **"testbed"** for India's human spaceflight capability.

## Adaptation Training

Will help Indian astronauts adapt to space environment **before Gaganyaan**.

# Indian launched into space

BAIKANOUR (USSR), April 3 (UNI, PTI).

India on Tuesday reached out for new frontiers of knowledge as Sqn Ldr Rakesh Sharma, with two fellow Soviet cosmonauts, soared into space aboard Soyuz T-11 for a historic rendezvous with the orbiting laboratory Salyut 7.

The Soviet spacecraft was hurled into an elliptical orbit [illegible]

India's first spaceman, the world 138th cosmonaut and the 11th to fly with the Soviet cosmonauts in the "Intercosmos" programme.

Immediately word came from flight commander Yuri Malyshev that all was well aboard the spacecraft, which will orbit the earth 17 times before docking with Salyut-7 on Wednesday night.

Jubilant Indians, joined by [illegible]

Soyuz T-11 orbits the earth once every 88.6 minutes at an apogee of 228 km and a perigee of 202 km. It will draw level with Salyut 7 at an altitude of 300 km before docking.

While the countdown was nearing the finale, Sqn Ldr Sharma, Commander Malyshev and cosmonaut Genadi Strekalov arrived at the foot of the [illegible]

[illegible] nations in Russian and Hindi respectively.

Sqn Ldr Sharma said: "It is a great honour for a citizen of India to be a member of the international crew of the ship Soyuz T-11 in the joint manned flight and to have the possibility to conduct scientific experiments on board the space station Salyut 7.

"It is a special honour to [illegible]

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# Historical Context & Comparison

### 1984: Rakesh Sharma

**Rakesh Sharma** was the first Indian in space, but flew with Soviet support and limited experimental return.

1

### 2027: Gaganyaan

India's first independent human spaceflight mission, building on previous experiences.

3

2

### 2025: Shubhamshu Shukla

Shukla's ISS visit allows for **advanced science and autonomy**, unlike Sharma's restricted schedule.

# Way Forward for India's Space Program

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## Planetary Missions

Mars, Sun, Venus missions

## Commercial Success

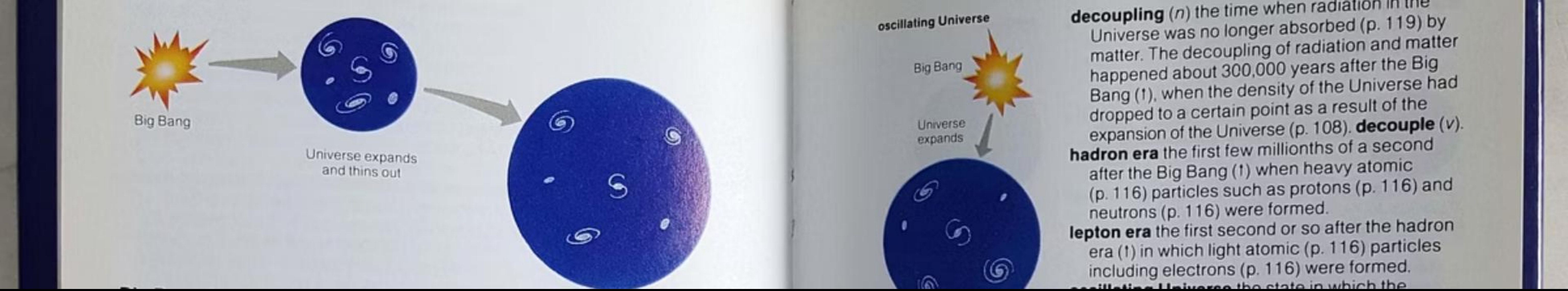
Private satellite launches

## Future Technologies

Reusable launch vehicles

## Space Habitation

Manned space stations

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# Key Terms

### ISS (International Space Station)

A modular space station in low Earth orbit, housing astronauts for research.

### Tardigrades

Microscopic, resilient organisms used to study survival in extreme conditions.

### Axiom Space

A private American space company facilitating commercial space travel.

### Gaganyaan Mission

India's upcoming maiden human spaceflight mission.

# GSLV & PSLV

# Why in News (May 2025)?

- **ISRO recently launched a GSLV-F14 mission**

  with the advanced INSAT-3DS meteorological satellite.

- **PSLV-C58 mission was launched earlier in 2024**

  successfully placing scientific payloads in different orbits using POEM-3 (PSLV Orbital Experimental Module).

- **These developments reaffirm India's capabilities**

  in both geo-stationary and polar orbit missions and make GSLV and PSLV relevant for competitive exams.

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# What are GSLV and PSLV?

## GSLV (Geosynchronous Satellite Launch Vehicle)

- A launch vehicle designed to **carry heavy payloads (up to 2,500 kg)** to **Geostationary Transfer Orbits (GTO)**.
- Mainly used to **launch communication, weather, and navigation satellites**.
- Includes an advanced **cryogenic upper stage**, making it a more complex system.

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# 2. PSLV (Polar Satellite Launch Vehicle)

Known as ISRO's "workhorse," PSLV is used for launching **low to medium-weight satellites** (up to 1,750 kg) into **Polar and Sun-Synchronous Orbits (SSO)**.

Has launched more than **300 foreign satellites** and **interplanetary missions** like Chandrayaan-1 and Mars Orbiter Mission.

# Background & Development

| Vehicle | First Flight | Developed By | Purpose |
|---|---|---|---|
| PSLV | 1993 | ISRO | To launch remote sensing satellites into polar orbits |
| GSLV | 2001 | ISRO | To place heavy communication satellites into geostationary orbits |




# Key Features

## PSLV

### Four-stage rocket

with alternate solid and liquid propulsion stages.

### Highly reliable

Over **95% success rate**.

### Used for missions to the Moon (Chandrayaan-1) and Mars (MOM)

### Can deploy satellites in multiple orbits

using POEM module.


# GSLV

Three-stage rocket

with a **cryogenic upper stage** (developed indigenously).

Used for launching heavier communication satellites

Capable of placing satellites in GTO (~36,000 km)

GSLV Mk III (renamed LVM3)

is India’s heaviest and most powerful launcher.

# Difference Between GSLV and PSLV

| Feature | PSLV | GSLV |
|---|---|---|
| Orbit | Polar / Sun-synchronous | Geosynchronous Transfer Orbit |
| Payload Capacity | ~1,750 kg to SSO | ~2,500 kg to GTO |
| Stages | 4 (solid-liquid alternation) | 3 (liquid-solid-cryogenic) |
| Reliability | Higher (Workhorse of ISRO) | Moderate (complex cryo stage) |
| Cryogenic Stage | Not used | Used (essential for GTO missions) |
| Applications | Earth observation, remote sensing, foreign satellite launches | Communication, meteorology, strategic payloads |

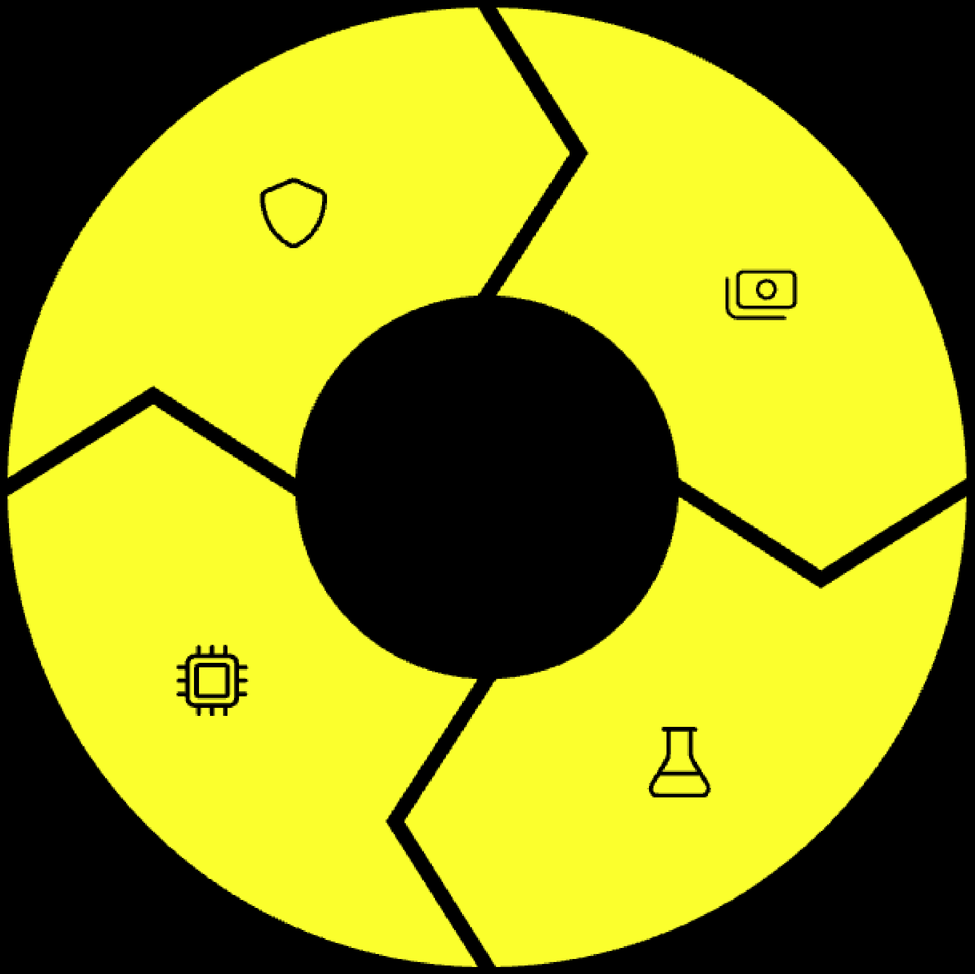
# Significance

### Strategic autonomy

Indigenous capability to launch various satellites, including defense and weather satellites.

### Technological milestone

India joins select nations with cryogenic engine tech via GSLV.

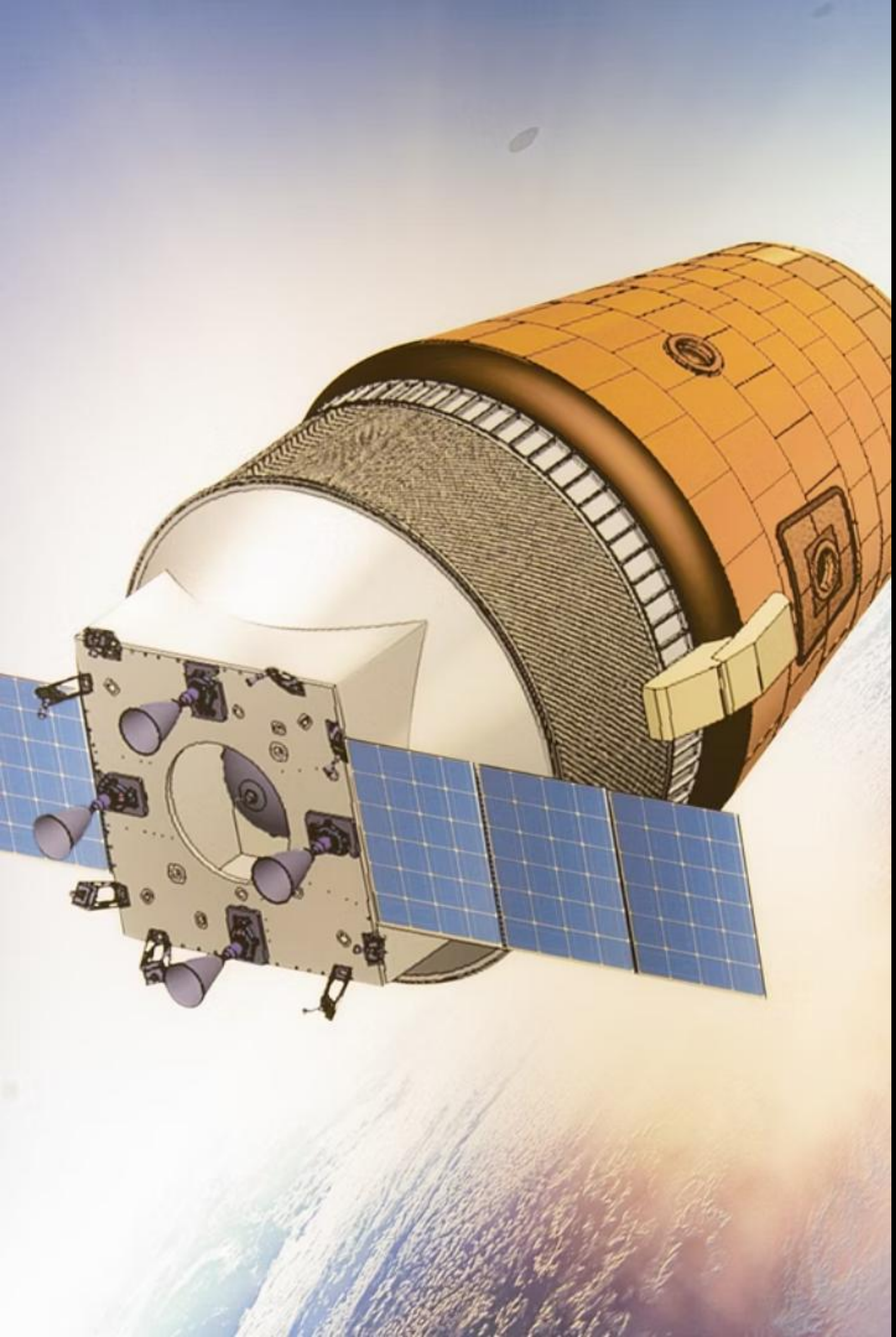


### Commercial benefit

Attracts global clients due to low-cost, reliable launches (especially PSLV).

### Scientific exploration

Enabler for Chandrayaan, Mangalyaan, and upcoming **Gaganyaan (human spaceflight)**.





# India's Human Spaceflight Programme - Gaganyaan, Axiom-4, and Bhartiya Antariksh Station (BAS)

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# Why in News?

## ISRO Chairman V. Narayanan confirmed that:

- India's first uncrewed Gaganyaan mission will launch in Q4 of 2025.
- Crewed Gaganyaan mission is scheduled for Q1 of 2027.
- The Axiom-4 mission, carrying Indian astronaut Subhranshu Shukla to the International Space Station (ISS), will launch in June 2025.

## Long-term Goal

These milestones are essential precursors to India's long-term goal: the Bhartiya Antariksh Station (BAS), expected to be operational in the early 2030s.

# 1. Gaganyaan Mission – India's First Human Spaceflight Programme

### Objective

Send Indian astronauts (Vyomanauts) into low-Earth orbit (~400 km).

### Duration

1–3 days in space.

### Vehicle

Human-rated LVM-3 (GSLV Mk-III).

### Total Budget

Approx. ₹10,000 crore.

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# Timeline:

| Mission Phase | Schedule |
|---|---|
| 1st Uncrewed Flight | Q4, 2025 |
| 2nd & 3rd Uncrewed | 2026 (TBD) |
| Crewed Flight | Q1, 2027 |

# 2. Axiom-4 Mission – India's Next Astronaut in Space

## Highlights:

- Indian Air Force pilot Subhranshu Shukla to travel to the ISS.
- First Indian astronaut to visit the ISS.
- Mission is part of an ISRO–NASA agreement.
- India investing ₹550 crore in the mission, including:

- Training

- Experimentation

- Equipment

## Crew Composition:

| Name | Country | Role |
|---|---|---|
| Peggy Whitson | USA | Mission Commander |
| Subhranshu Shukla | India | Pilot |
| Sławosz Uznański | Poland | Mission Specialist |
| Tibor Kapu | Hungary | Payload Specialist |

# Mission Objectives:

## Microgravity experiments on:

- Human health
- Crop growth

## Astronaut Experience

Builds astronaut experience needed for Gaganyaan

## Cultural Integration

Shukla will carry Indian food such as moong dal halwa, mango nectar, and rice variants.




# 3. Science & Strategic Utility of Axiom-4

## ISRO's Experiment Focus

7+ biological and scientific experiments:

- Health monitoring in space
- Crop germination in microgravity
- System diagnostics
- Habitability assessments

## Strategic Benefit

- Enhances India's readiness for Gaganyaan
- Builds inter-agency coordination (ISRO-NASA-SpaceX)
- Prepares ground for long-duration missions in future Indian space stations

# 4. Bhartiya Antariksh Station (BAS) – India's Own Space Station

### Vision

Announced by former ISRO chief K. Sivan, reaffirmed by current leadership.

### Plan

India plans to build and operate an indigenous space station in low-Earth orbit (LEO).

# Proposed Timeline:



### Initial planning

Began in 2019.

### Operational window

By early 2030s.

### Development Process

Gaganyaan experience and Axiom-4 data will feed directly into the design and operations of BAS.

## Key Objectives of BAS:

- Support long-term human missions.
- Enable microgravity research, space medicine, and materials science.
- Host international astronauts.
- Act as a platform for national defence and commercial space research.

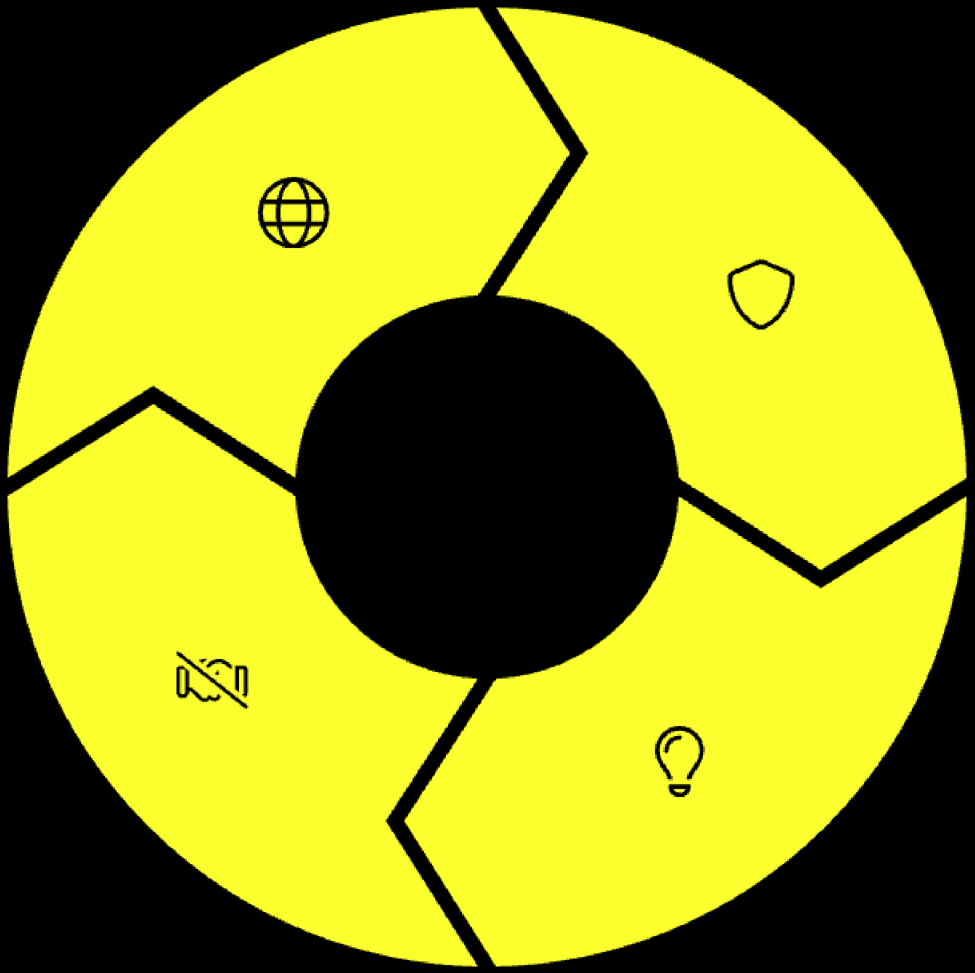
# Strategic Importance

### Scientific Advancement

Pushing boundaries in space science and technology

### Strategic Sovereignty

Establishing independent capabilities in space



### Soft Power Diplomacy

Enhancing India's global influence

### Economic Innovation

Driving new industries and technologies

This integrated roadmap is essential not just for science and technology, but for India's strategic sovereignty in space, economic innovation, and soft power diplomacy.

# Conclusion

## Space Station

BAS will place India among elite space powers with permanent orbital capabilities.

## International Collaboration

Axiom-4 is a stepping stone offering astronaut experience and microgravity research.

## Human Spaceflight

Gaganyaan will make India a human spaceflight nation.


# CMS-03 Satellite

# Introduction – What is CMS-03

- **Full Name:** Communication Satellite CMS-03 (also designated as GSAT-7R)
- **Announced by:** Indian Space Research Organisation (ISRO) on 28 October 2025.




- Launch Vehicle: LVM3 (Launch Vehicle Mark 3)
- Significance: First mission by LVM3 after over two years; India's heaviest communication satellite to be launched to Geosynchronous Transfer Orbit (GTO).
- Orbit Type: GTO (Geosynchronous Transfer Orbit) → eventually to GEO (Geostationary Earth Orbit) for long-term operations.

# Mission Purpose & Strategic Significance

**Core Purpose:** Strengthen India's space-based communication infrastructure and expand telecommunication coverage across India and adjacent oceanic regions.

**Strategic Applications:**

- Supports naval communication networks: ships, submarines, aircraft of the Indian Navy.
- Enhances civilian broadband/telecom services to remote and underserved areas.

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**Dual Use:** Combines civilian telecommunications with defence / maritime communications, underlining the overlap of technology & security in space domain.

**Oceanic Region Coverage:** Focus on Indian landmass + adjacent seas (Indian Ocean, Indian Ocean Rim) for maritime domain awareness.

# Technical Specifications

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- Payload: Multi-band transponders supporting voice, data, and video links.
- Covers C-band, Extended C-band, and Ku-band.
- **Mass / Weight: ~ 4,400 kg (4.4 tonnes) — India's heaviest communication satellite to date.**

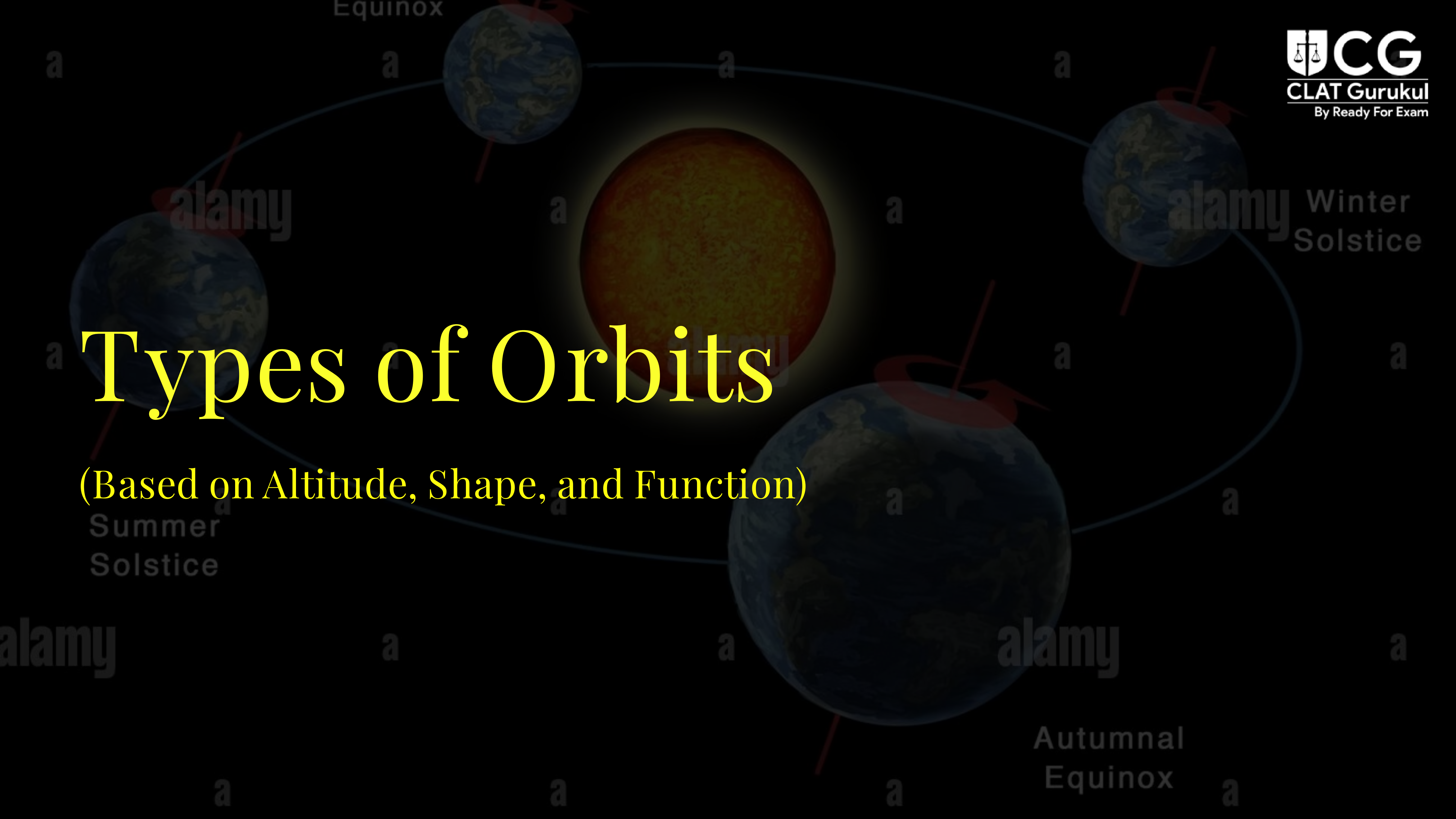
**Orbit & Life:** Placed into GTO then to GEO at approx ~36,000 km altitude; expected mission life ~15 years (typical for such satellites).

# Key Concepts & Terminology

- Geosynchronous Transfer Orbit (GTO): Elliptical orbit used to transfer satellite to GEO; perigee ~200-300 km, apogee ~36,000 km.
- Geostationary Earth Orbit (GEO): Circular orbit at ~35,786 km altitude where a satellite appears stationary relative to Earth's rotation — ideal for communication satellites.
- Transponder: Device that receives, amplifies, and retransmits signals; defines capacity of communication satellite.

# Types of Orbits

(Based on Altitude, Shape, and Function)

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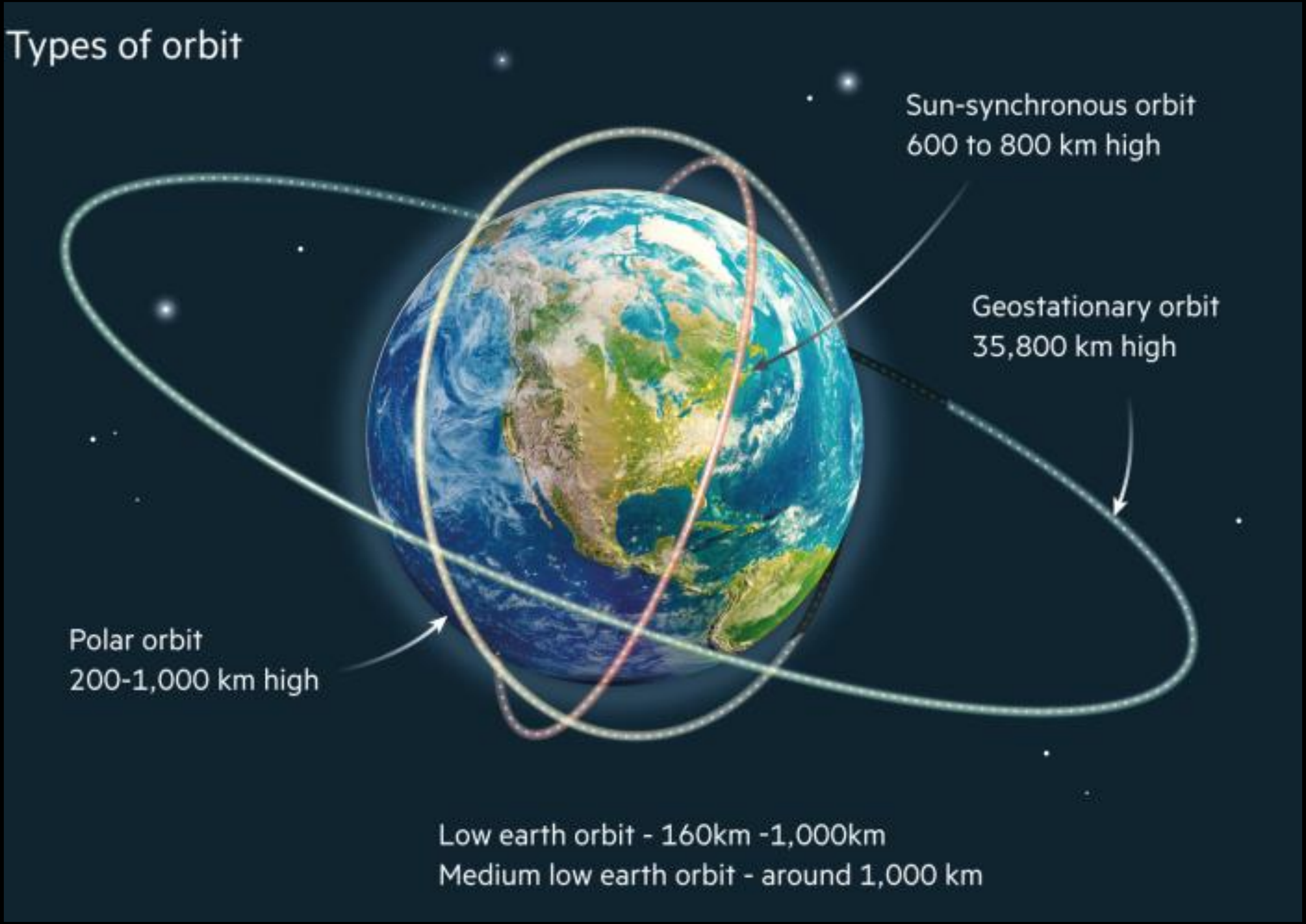
Types of orbit
Sun-synchronous orbit
600 to 800 km high
Geostationary orbit
35,800 km high
Polar orbit
200-1,000 km high
Low earth orbit - 160km -1,000km
Medium low earth orbit - around 1,000 km

# Based on Altitude (Height from Earth's Surface)



| Orbit Type | Altitude Range | Key Features & Applications | Examples |
|---|---|---|---|
| Low Earth Orbit (LEO) | ~200 km – 2,000 km | • Short orbital period (≈ 90 minutes).• High-resolution imaging and low latency communication.• Used for Earth Observation, Remote Sensing, and Space Stations. | ISS (~408 km), Cartosat, RISAT, OneWeb satellites |
| Medium Earth Orbit (MEO) | ~2,000 km – 35,786 km | • Longer period than LEO.• Used for navigation and communication. | GPS, Galileo, IRNSS/NavIC (~36,000 km inclined) |

| Orbit Type | Altitude Range | Key Features & Applications | Examples |
|---|---|---|---|
| Geostationary Earth Orbit (GEO) | Exactly 35,786 km above equator | • Appears stationary relative to Earth's rotation (same rotational speed).• Used for Communication, Weather, TV, and Broadcasting satellites. | INSAT series, GSAT series, METSAT |
| High Earth Orbit (HEO) | > 35,786 km | • Covers large area, used for astronomy or highly elliptical communication. | GOES (Weather), Tundra Orbit satellites |

# Based on Shape

| Orbit Type | Description | Use |
| --- | --- | --- |
| Circular Orbit | Constant altitude; used for stable communication or observation. | Communication (GEO), Remote sensing |
| Elliptical Orbit | Variable altitude (perigee & apogee). Used for long-duration visibility over high latitudes. | Molniya, Tundra orbits (Russia) |

# Based on Orientation / Inclination

| Orbit Type | Inclination / Orientation | Applications |
|---|---|---|
| Equatorial Orbit | Lies over the equator (0° inclination). | Geostationary communication satellites. |
| Polar Orbit | Passes over both poles (≈ 90° inclination). Earth rotates under it, enabling global coverage. | Cartosat, Resourcesat, RISAT (remote sensing). |

| Orbit Type | Inclination / Orientation | Applications |
|---|---|---|
| Sun-Synchronous Orbit (SSO) | Special near-polar orbit (~98° inclination); crosses each point at same local solar time → consistent lighting conditions. | Meteorological, mapping, reconnaissance satellites. |
| Inclined Orbit | Tilted with respect to equator (not polar or equatorial). | Navigation (IRNSS/NavIC). |

# Based on Function

| Orbit Type | Function / Purpose | Examples |
|---|---|---|
| Geostationary Orbit (GEO) | Communication, TV, Weather | GSAT, INSAT |
| Sun-Synchronous Orbit (SSO) | Earth Observation, Remote Sensing | Cartosat, Resourcesat |
| Polar Orbit | Global Mapping | RISAT |

| Orbit Type | Function / Purpose | Examples |
|---|---|---|
| Transfer Orbit (GTO) | Temporary orbit to reach GEO | CMS-03 (GSAT-7R) |
| Highly Elliptical Orbit (HEO) | Long dwell time over specific regions | Tundra, Molniya satellites |
| Medium Earth Orbit (MEO) | Navigation Systems | GPS, NavIC |
| Low Earth Orbit (LEO) | Earth Observation, Starlink constellations | OneWeb, Amazon Kuiper |

# Space Stations: Past, Present & Future

# What is a Space Station?

- A space station is a large spacecraft designed for humans to live and work in space for extended periods.
- It remains in Low Earth Orbit (LEO) and serves as a research laboratory for space science, microgravity experiments, Earth observation, and astronomy.
- Unlike spacecraft, it doesn't have its own propulsion for orbital transfer — depends on supply missions for crew, cargo, and fuel.

# Chronological Overview of Space Stations

| Era | Name / Country | Operational Period | Significance |
|---|---|---|---|
| 1971 | Salyut 1 (USSR) | 1971 (6 months) | World's first space station. |
| 1973–74 | Skylab (USA) | 1973–1974 | USA's first space station, operated by NASA. |
| 1977–2001 | Salyut series (USSR) | 1971–1986 | Advanced Soviet stations, pathfinders for Mir. |
| 1986–2001 | Mir (USSR/Russia) | 1986–2001 | First modular, permanently crewed station; record for longest continuous human presence before ISS. |

Era

1998–Present

Name / Country

International Space Station (ISS)

Operational Period

1998–present

Significance

Largest cooperative scientific platform in space (NASA, Roscosmos, ESA, JAXA, CSA).

Era

2011–2013

Name / Country

Tiangong 1 (China)

Operational Period

2011–2018

Significance

China's first prototype station; entry to space station era.

Era

2016–2019

Name / Country

Tiangong 2 (China)

Operational Period

2016–2019

Significance

Testbed for docking, life support, long-duration stays.

Era

2021–Present

Name / Country

Tiangong / CSS (China)

Operational Period

2021–present

Significance

Fully operational Chinese Space Station (in orbit).

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# The International Space Station (ISS)

- Launch: Began 1998 (Zarya module); continuously inhabited since November 2000.
- Partners:
- NASA (USA)
- Roscosmos (Russia)
- ESA (Europe)
- JAXA (Japan)
- CSA (Canada)

1

## Orbit

LEO (~400 km altitude).

2

## Speed

7.66 km/s → ~16 orbits per day.

3

## Crew

Typically 6–7 astronauts on rotation.

4

## Functions

- Life-science & microgravity experiments.
- Materials & combustion research.
- Earth & space observation.

5

## Structure

Modular — US Lab Destiny, Russian Zvezda, European Columbus, Japanese Kibo, Canadian Canadarm2.

# Strategic & Scientific Significance of ISS

- Largest international collaboration in history.
- Provides continuous human presence in space (> 24 years).
- Basis for biological studies for long-duration human missions (Mars prep).
- Used for Earth observation (climate data), space-based education, and robotics testing.
- Will likely operate till 2030, after which it will be replaced by private/commercial stations.

# China's Tiangong Space Station (Present)

| Parameter | Details |
|---|---|
| Name | Tiangong (means "Heavenly Palace"). |
| Country | People's Republic of China (CNSA). |
| Modules | Tianhe (core module), Wentian, Mengtian. |
| Launch Timeline | 2021–2022; fully operational since late 2022. |

| Parameter | Details |
| --- | --- |
| Orbit | LEO (400 km), similar to ISS inclination (42°). |
| Crew Capacity | 3 permanent astronauts (taikonauts). |
| Lifespan | 15 years (planned till ~2038). |
| Scientific Goals | Space medicine, materials science, Earth observation, technology testing. |
| Significance | Makes China only the third nation to independently build and operate a modular space station (after USA & USSR/Russia). |

# Future Space Stations (Planned)

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| Station | Country / Organization | Planned Operational Period | Key Details |
|---|---|---|---|
| Axiom Space Station (Axiom-1) | USA (Private, with NASA support) | From 2026 | Initially attached to ISS; will detach to become first private space station. |
| Orbital Reef | Blue Origin + Sierra Space (USA) | Late 2027–2028 | "Business park in space"; supports research, tourism, and manufacturing. |
| Starlab | Voyager Space + Airbus Defence (USA/EU) | Late 2027 | 8 m-diameter module; aims for continuous research occupancy. |

| Station | Country / Organization | Planned Operational Period | Key Details |
| --- | --- | --- | --- |
| Russian ROSS (Russian Orbital Station) | Russia (Roscosmos) | Early 2030s | To replace Russia's ISS segment; focus on high-latitude Earth observation. |
| Indian Space Station (ISRO Proposal) | India (ISRO) | Target ~ 2035 | Small modular station (~20 tons), post-Gaganyaan mission; focus on microgravity research, human health, and space medicine. |

# India's Future Space Station – Overview

- Announced by: Former ISRO Chairman K. Sivan (2019).
- Target Timeline: Mid-2030s (after sustained success of Gaganyaan crewed mission).
- Proposed Features:
- Orbit: ~400 km (LEO).
- Mass: ~20 tons.
- Crew Capacity: 2–3 astronauts for 15–20 days.
- Focus Areas: Space medicine, biological sciences, material research in microgravity.
- Linked Missions:
- Gaganyaan (India's human spaceflight mission).
- Vyommitra (Indian humanoid robot test mission).

# Crew Escape System

# Introduction – What is the Crew Escape System (CES)

- Full Name: Crew Escape System (CES) for the Gaganyaan human spaceflight programme.
- Programme: Part of India's Human Spaceflight Programme (HSP) under Indian Space Research Organisation (ISRO).
- Purpose: A safety mechanism to rapidly separate the crew-module (with the astronauts) from the launch vehicle in the event of an emergency during launch or ascent, ensuring safe descent and recovery.

1

Key Milestone:

2

**Pad-Abort Test (PAT)** on 5 July 2018: CES with simulated crew module (12.6 tonne) reached altitude ~2.7 km, then landed safely.

3

**In-Flight Abort Test (TV-D1)** on 21 October 2023: Demonstrated CES separation at higher speed/altitude.

# Chandrayaan-5 / LUPEX

# Introduction – Chandrayaan-5 / LUPEX

- Mission Name: Chandrayaan-5 (LUPEX: Lunar Polar Exploration)
- Partners: Indian Space Research Organisation (ISRO) + Japan Aerospace Exploration Agency (JAXA)
- Approval Status: Financial sanction by Government of India in March 2025.
- Target Launch: 2027-2028 timeframe (subject to revision)
- Primary Objective: Explore the Moon's south polar region (including Permanently Shadowed Regions – PSRs) to study lunar water/ice deposits and lunar volatiles.

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# Mission Details & Key Specifications

01

## Launch Vehicle

JAXA's H3-24L rocket (for this mission)

02

## ISRO Role

Development of the lunar lander module; designing certain scientific instruments.

03

## JAXA Role

Development of the lunar rover (approx. 350 kg) and launch vehicle provision.

04

## Scientific Payloads

Eight (or seven) scientific instruments including contributions from ESA (mass spectrometer) and NASA (neutron spectrometer) planned.

05

## Mission Duration Plan

Base mission ~100 days (≈ 3.5 months); possible extension up to a year.

# Information Technology Act, 2000

India's foundational legislation for electronic commerce, digital signatures, and cyber law

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Basic Details

# Information Technology Act, 2000

| Act No. | Date of Assent | Commencement |
| --- | --- | --- |
| 21 of 2000 | 9 June 2000 | 17 October 2000 |

**Purpose (Long Title):** "An Act to provide legal recognition for transactions carried out by means of electronic data interchange and other means of electronic communication... to facilitate electronic filing of documents with the Government agencies and further to amend the Indian Penal Code, the Indian Evidence Act, 1872 ..."

**Applicability:** Whole of India; some provisions apply extraterritorially.

Key Objectives & Features

# Objectives

### Legal Recognition

Provide legal recognition for electronic/computer-based transactions & records.

### E-Governance

Facilitate e-governance and electronic filing of documents.

### Cyber-Crimes

Define cyber-crimes and prescribe penalties.

# Important Sections & Offences



1

### Section 65

Tampering with computer source documents.

2

### Section 66

Hacking with computer system.

3

### Section 69A

Power to block access of information by government (on grounds of sovereignty, security).

4

### Section 79

Liability of intermediaries.

**Note:** Section 66A (offensive messages) was struck down by the Supreme Court in Shreya Singhal v. Union of India (2015).

**Amendment:** Information Technology (Amendment) Act, 2008 introduced additional offences (cyber terrorism, child pornography) and expanded powers.

Applicability, Amendments & Related Rules

# Scope & Applicability

Applies to electronic/computer resources & offences committed outside India by persons if computer resource is located in India.

**Major Amendment:** 2008 Amendment Act (came into effect 27 Oct 2009) expanded scope.

Related Static & Conceptual Facts

# Ministry & Agencies

**Ministry:** Ministry of Electronics & Information Technology (MeitY) is the nodal ministry overseeing IT Act implementation.

## Important Agencies

### Controller of Certifying Authorities (CCA)

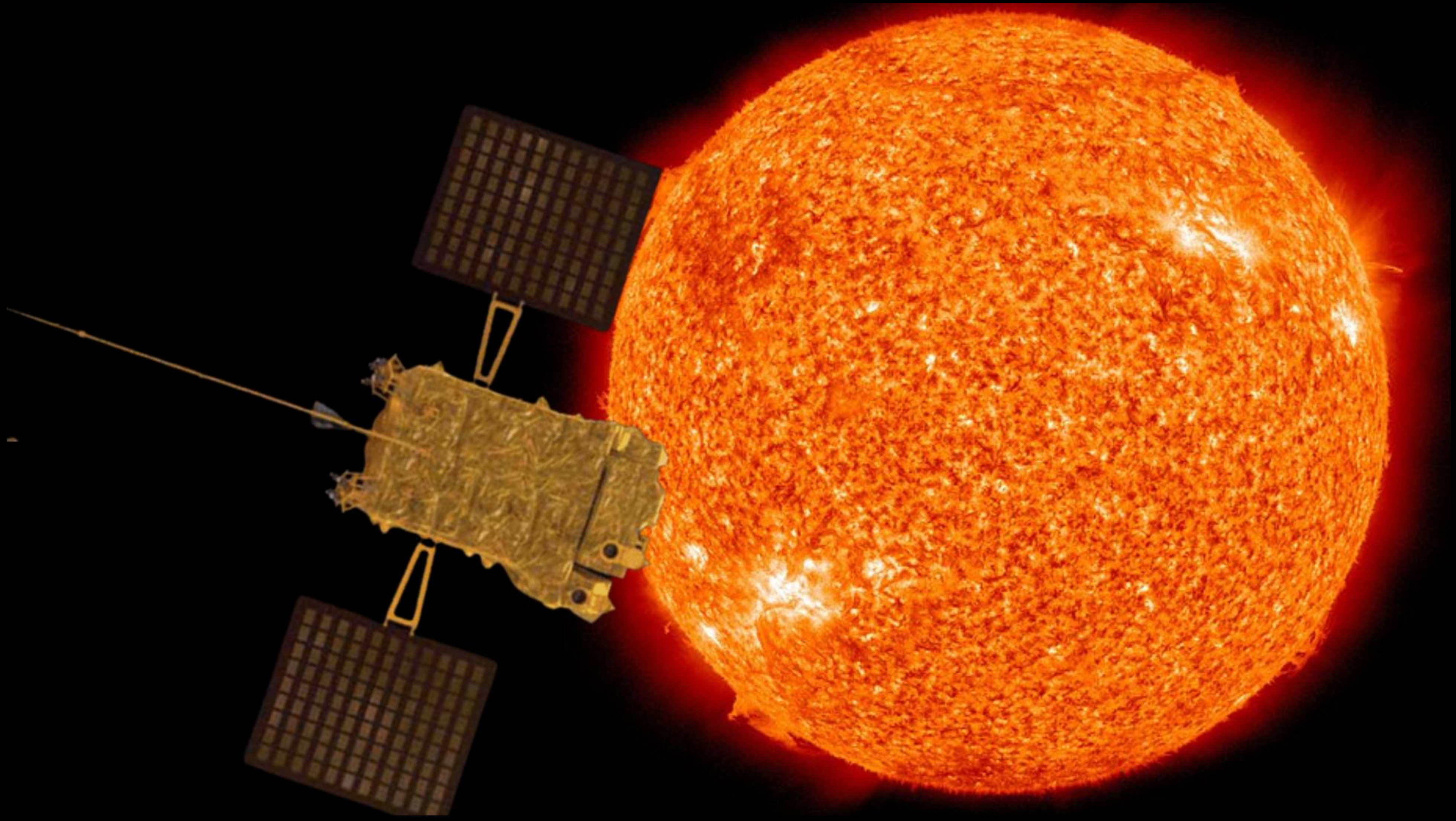
Under MeitY

### CERT-In

Indian Computer Emergency Response Team (cyber-security incident response)

# India's First Solar Observatory Mission

## Aditya-L1

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ADITYA-L1

Introduction & Mission Overview

# Aditya-L1

**Name:** Aditya-L1 (Sanskrit "Aditya" = Sun; "L1" refers to the Sun–Earth Lagrange Point 1)

**Organisation:** Indian Space Research Organisation (ISRO)

**Launch Date:** 2 September 2023 aboard the PSLV-XL C57 from Satish Dhawan Space Centre, Sriharikota.

**Destination Orbit:** A halo orbit around the Sun–Earth Lagrange Point 1 (L1) located about 1.5 million km from Earth.

**Purpose:** First Indian space observatory mission to study the Sun's outer layers (photosphere, chromosphere, corona), solar wind, particles & magnetic field environment from L1.

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Scientific Objectives & Key Features

# Mission Capabilities

### Continuous View

At L1 the spacecraft has uninterrupted line-of-sight to the Sun without Earth-occultation/ eclipses.

### Seven Payloads

Seven scientific instruments (4 for remote sensing of Sun, 3 for in-situ measurements at L1) developed indigenously.

# Science Themes

### Coronal Heating

Study of coronal heating (why Sun's corona is hotter than surface)

### Solar Activity

Analysis of solar flares, coronal mass ejections (CMEs), solar wind & space weather effects on Earth.

### Magnetic Field

Monitoring of solar magnetic field and particle environment at L1.

**Orbit/Trajectory Details:** Initial Earth-bound orbit raising manoeuvres → Trans-Lagrangian injection → Halo orbit at L1 (~177-day period)

Technical & Conceptual Terms Explained

# Key Concepts

**Lagrange Point (L1):** A point in space where gravitational forces of two large bodies (Sun & Earth) and the orbital motion of a smaller object combine to produce a stable location; L1 lies between Sun and Earth at about 1.5 million km from Earth.

**Halo Orbit:** A three-dimensional periodic orbit around a Lagrange point; enables spacecraft to "hover" relative to Sun and Earth while maintaining solar line-of-sight.

# Solar Terminology

## Corona

The outermost layer of the Sun's atmosphere, very hot, source of solar wind and CMEs.

## Chromosphere / Photosphere

Layers of the Sun; photosphere = visible "surface"; chromosphere = above photosphere.

## Solar Wind / Space Weather

Streams of charged particles and magnetic fields from the Sun; affect Earth's magnetosphere, satellites, power grids.

## Remote sensing vs In-situ

Remote sensing = observation from distance (Sun's surface, corona); in-situ = measurement where the spacecraft is (particles, fields at L1).

# Mission Details

| 2023 | 1.5M | 7 |
| --- | --- | --- |
| Launch Year | Distance (km) | Payloads |
| 2 September 2023 | From Earth to L1 | Scientific instruments |

**ISRO Headquarters:** Bengaluru, India.

**Launch Vehicle:** PSLV-XL C57 (Polar Satellite Launch Vehicle).

**Nodal Ministry:** Department of Space (DOS), Government of India.

# Important Dates

| Launch | Halo Orbit Insertion |
| --- | --- |
| 2 September 2023 | 6 January 2024 |

# Significance for India

First dedicated solar mission; advances Indian capability in heliophysics & space-weather monitoring.

**Global Context:** Complements other solar missions like NASA's Parker Solar Probe and ESA/NASA's Solar Orbiter.

# SpaDeX (Space Docking Experiment)

# Introduction & Mission Overview

**Mission Name:** SpaDeX (Space Docking Experiment)

**Organization:** ISRO (Indian Space Research Organisation)

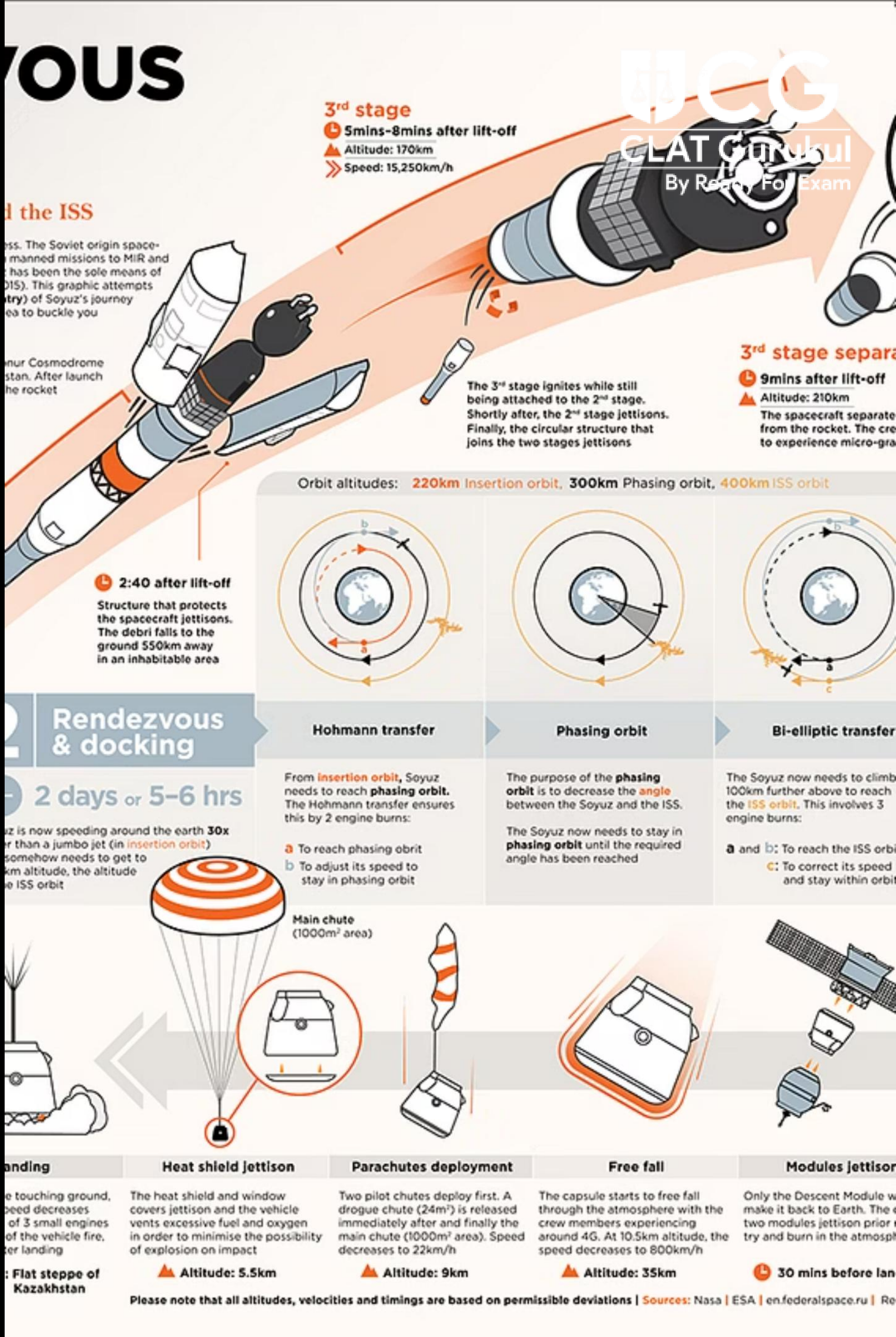
**Launch Date:** 30 December 2024 aboard PSLV-C60 from Satish Dhawan Space Centre, Sriharikota.

**Mission Type:** Technology demonstrator mission for in-space rendezvous, docking & undocking using two small satellites.

**Significance:** With successful docking and undocking, India becomes the fourth country after the USA, Russia and China to master space-docking technologies.

# Key Objectives & Mission Design

**Primary Objective:** Develop and demonstrate technology needed for rendezvous, docking and undocking of two spacecraft (SDX01 – Chaser & SDX02 – Target) in Low Earth Orbit (LEO).



# Secondary Objectives

### Electrical Power Transfer

Demonstrate electrical power transfer between two docked spacecraft.

### Composite Spacecraft Control

Demonstrate composite spacecraft control (once docked, treated as one craft).

### Payload Operations

Payload operations of individual satellites after undocking.

# Mission Design Details

## Spacecraft Specifications

Two satellites each ≈ 220 kg.

**Orbit:** ~470 km circular orbit (initial separation ~20 km, then gradually closed to ~3 m before docking).

## Docking System

**Docking mechanism:** "Bharatiya Docking System" – indigenous mechanism.

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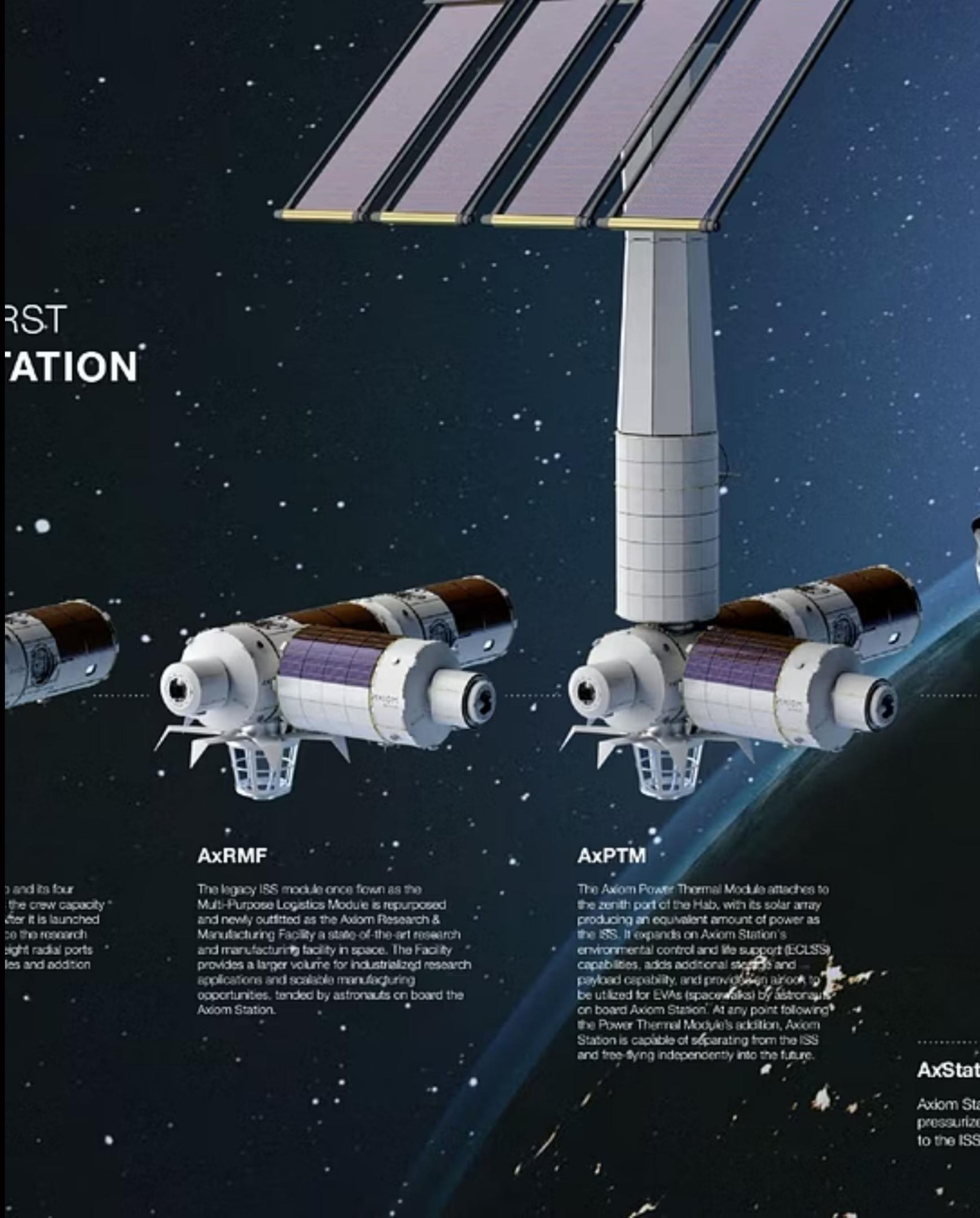
## Why it matters:

Such technologies are crucial for:

- Building multi-module space stations.
- In-orbit satellite servicing and refuelling.
- Crew transfer, lunar/exploratory missions.



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# Mission Milestones & Achievements

1

**30 December 2024**

Launch of SpaDeX satellites.

2

**16 January 2025**

Successful docking achieved.

3

**13 March 2025**

Undocking of the satellites completed, demonstrating full rendezvous-docking-undocking sequence.

India joined elite club of nations with docking capability; mission is a stepping stone for future missions such as lunar sample-return, India's space station (Bharatiya Antariksh Station) & human spaceflight.

# Other Facts


**SpaDeX stands for:** "Space Docking Experiment".

**Satellites:** SDX01 (Chaser), SDX02 (Target).

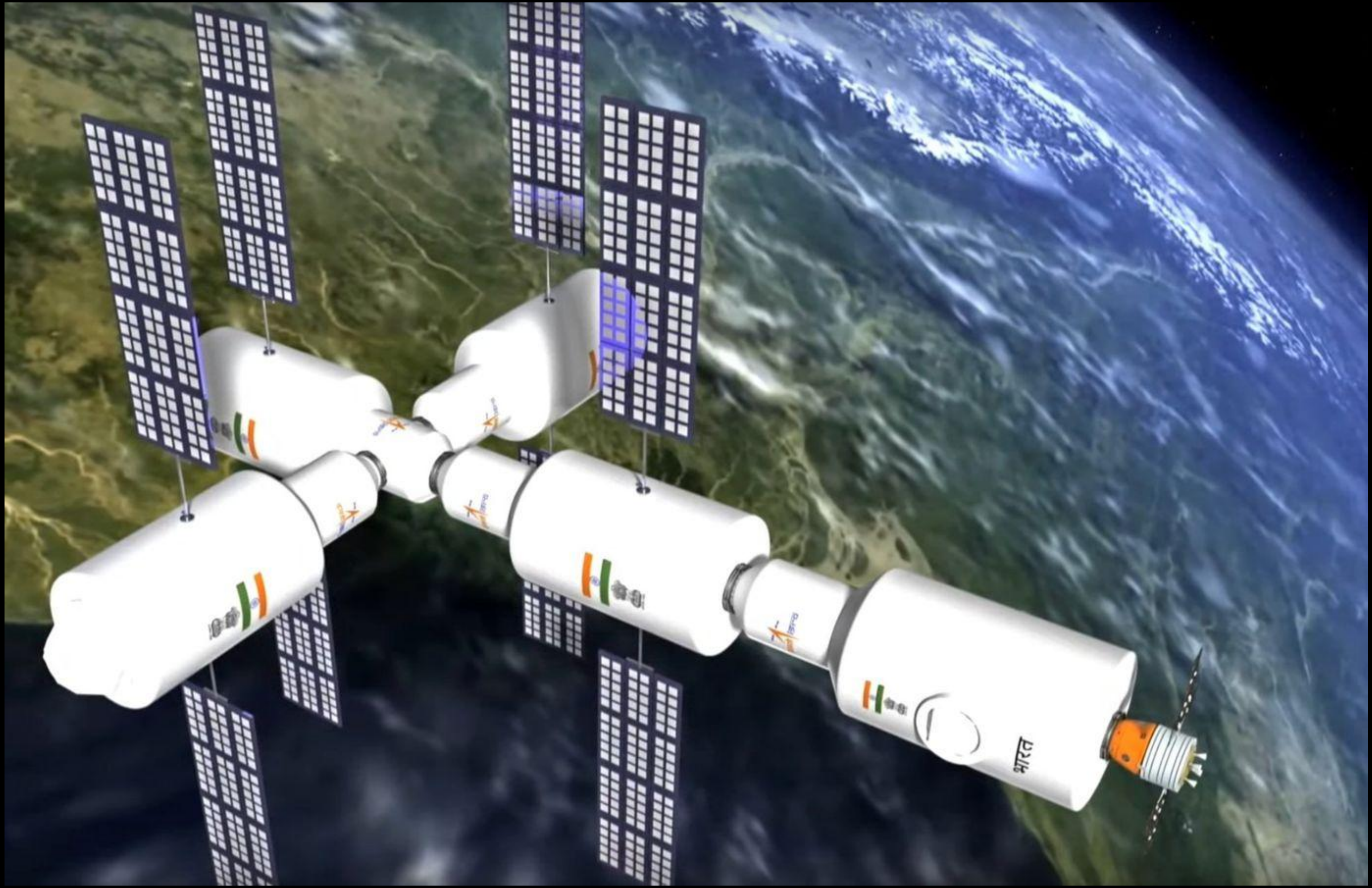
**Mission cost:** ~₹ 125 crore (as per media).

**Orbit:** ~470 km, inclination ~45° (approx).

**India became 4th country to achieve docking:** after USA, Russia, China.

# Bharatiya Antariksh Station (BAS)





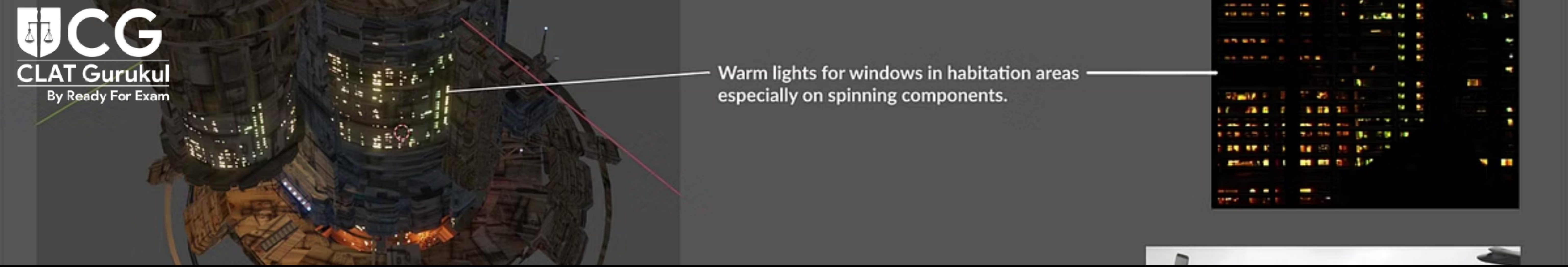
# Introduction – Bharatiya Antariksh Station (BAS)

**Name:** Bharatiya Antariksh Station (BAS)

**Announced by:** Indian Space Research Organisation (ISRO)

**Revealed by:** Dr. S. Somanath, ISRO Chairman (2023)

**Planned Launch Window:** By 2035




# BAS Overview

**Nodal Ministry:** Department of Space (DOS), Government of India

**Purpose:** India's first indigenously built modular space station designed for sustained human presence in Low Earth Orbit (LEO).

**Orbital Parameters:** Planned altitude ~400 km; inclination ~51.6° (similar to ISS for orbital synergy).

# Significance & Design

## Significance:

- Enhances India's space autonomy and human-spaceflight capabilities post-Gaganyaan.
- Enables long-duration crewed missions, micro-gravity research, and space manufacturing.

## Design:

Modular architecture — each module launched separately and assembled through in-orbit docking, technology validated in SpaDeX (2024–25).

# Technical Architecture & Role of SpaDeX

## Structural Composition:

### Core Module

Habitation and life-support systems.

### Laboratory Module

For micro-gravity research, materials science, biomedicine.

### Power Module

Solar arrays and storage units.

### Docking Module

Enables spacecraft and module attachment — SpaDeX technology directly integrated here.

# Technology Derived from SpaDeX

01

## Androgynous Docking Mechanism

Allows bidirectional docking (any module can connect).

02

## Autonomous Rendezvous Navigation

Based on GNSS-aided proximity ops from SpaDeX.

03

## Inter-Module Power Transfer

Validated during SpaDeX's in-orbit docking phase.

04

## Inter-Satellite Data Link (ISL)

Evolved into Inter-Module Communication Bus for BAS.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# SpaDeX ⤔ BAS Connection

## SpaDeX provided the proof-of-concept for all critical subsystems —

→ Docking interface ✅

→ Power/data exchange ✅

→ Attitude control after docking ✅

→ Undocking sequence ✅

## ISRO Roadmap Link:

SpaDeX → Gaganyaan → BAS — a continuum of capability from short-term crewed flights to long-duration space habitation.

# Broader Vision, Collaborations

## Strategic Objectives:

### Continuous Human Presence

Maintain continuous Indian human presence in space post-2035.

### R&D Capabilities

Conduct R&D in space medicine, materials engineering, astronomy, and agriculture.

### In-Orbit Services

Enable in-orbit servicing, refuelling, and technology testing for lunar/Mars missions.




# Human-Rated Launch Vehicle Mark-3 (HLVM3)



# Introduction & Basic Facts

- **Name:** Human-Rated Launch Vehicle Mark-3 (HLVM3)
- **Organisation:** Indian Space Research Organisation (ISRO) under the Department of Space, Government of India.
- **Purpose:** A human-rated version of the existing Launch Vehicle Mark-3 (LVM3) (ex-GSLV Mk III) adapted for India's crewed mission programme (Gaganyaan) and future human spaceflight.

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## Key Specifications:

- Three-stage launch vehicle
- Height: approx. 53 m
- Mass: approx. 640 tonnes
- Payload capacity to Low Earth Orbit (LEO): ~10 tonnes

# Human-Rating & Safety Features

**Human-Rating** means the vehicle is adapted for safe crewed launch: enhanced reliability, redundancy, special safety systems.

## Safety Features include:

### Crew Escape System (CES)

To quickly eject the crew module in case of an emergency during ascent.

### Lower Acceleration

Lower acceleration during ascent (for crew comfort) and more stringent component qualification.

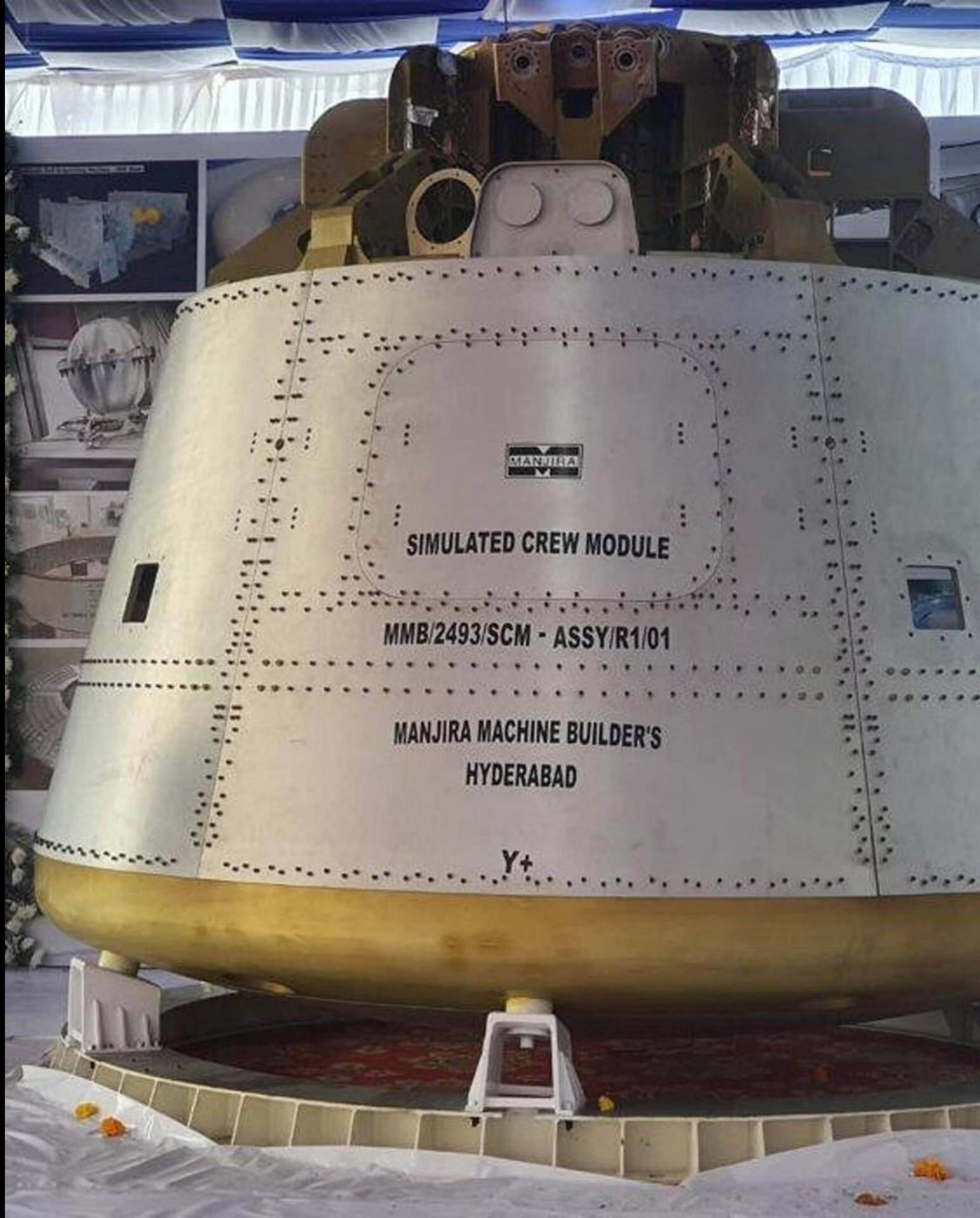
### Redundancy Systems

Redundancy in critical subsystems: guidance, navigation, health-monitoring systems.

**Derived from LVM3 heritage:** HLVM3 builds on LVM3's proven launch performance but "human-rates" it.

# Linkage with Gaganyaan & Future Missions

- HLVM3 is the launch vehicle selected for India's Gaganyaan programme — the country's first major human spaceflight mission.
- The first uncrewed test flight of Gaganyaan (G-1) will be launched on HLVM3.
- HLVM3 also acts as a stepping-stone for future Indian space ambitions: e.g., the planned Bharatiya Antariksh Station (India's own modular space station).
- It enables India's human-space capability: launching crew modules, docking, longer duration missions.



# Related Static Facts

### HLVM3

Human-Rated Launch Vehicle Mark-3

### LVM3

Launch Vehicle Mark-3 (ex-GSLV Mk III)

### CES

Crew Escape System

### LEO

Low Earth Orbit

### ISRO

Indian Space Research Organisation

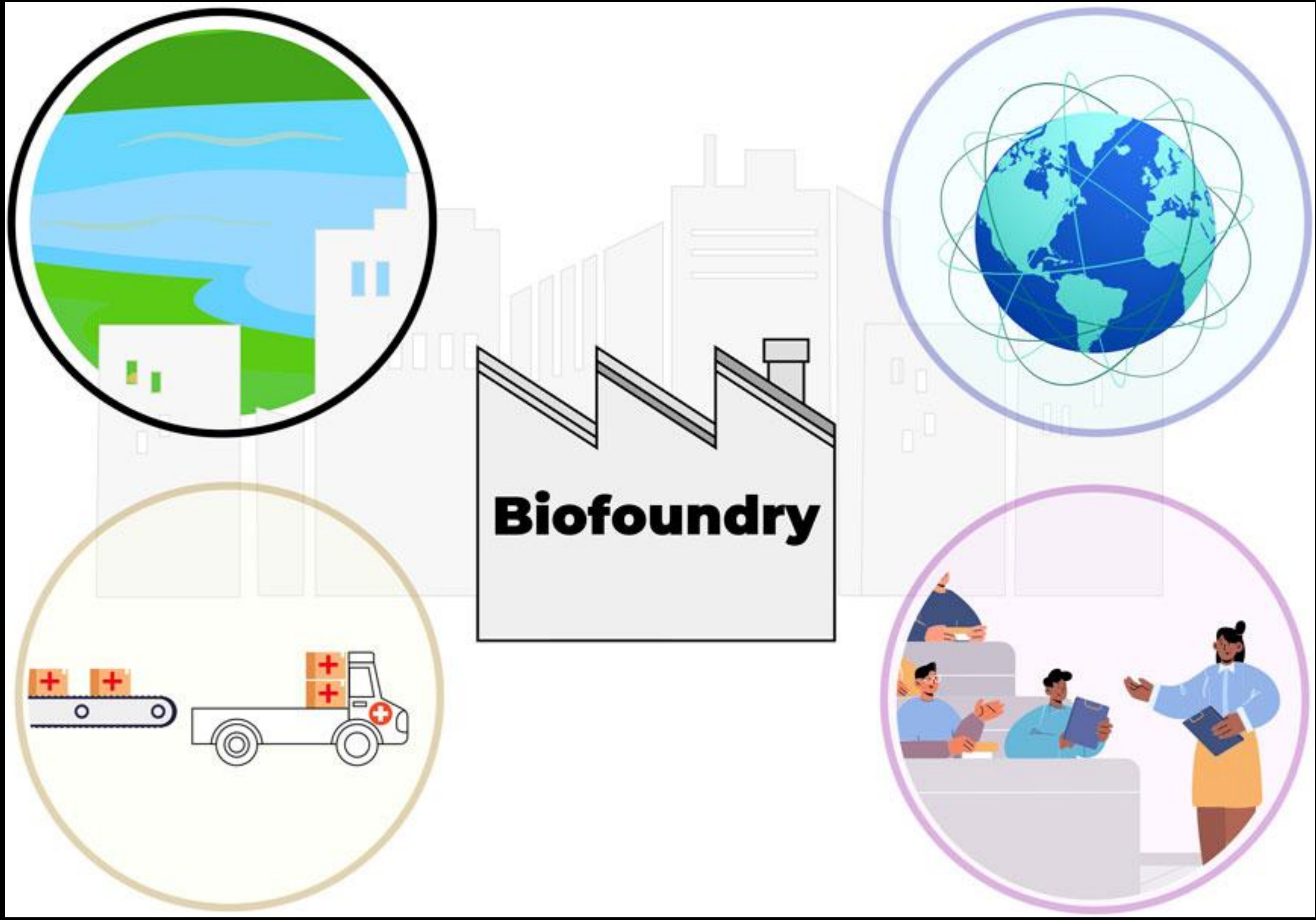
### DOS

Department of Space (Government of India)

## Other Related Facts:

- ISRO headquarters: Bengaluru, India.
- Launch Site: Satish Dhawan Space Centre (SDSC SHAR), Sriharikota.
- Gaganyaan's crew module and service module development linked closely with HLVM3's human-rated systems.

# National Biofoundry Network



# National Biofoundry Network

**Full Name:** National Biofoundry Network (NBN)

**Launched:** 27 August 2025 by the Department of Biotechnology (DBT) under the BioE3 Policy ("Biotechnology for Economy, Environment and Employment").

**Nodal Ministry:** Ministry of Science & Technology (MoS&T) through DBT.

# Objective & Bioeconomy Context

**Objective:** To create a national-level network of biofoundries (shared biomanufacturing + synthetic biology facilities) to accelerate translation of biotech innovations (lab → market), strengthen indigenous biomanufacturing and position India as a global bioeconomy hub.

**Bioeconomy Context:** India's bioeconomy grew from ~US $10 billion in 2014 to ~US $165.7 billion in 2024; target of US $300 billion by 2030.

# Key Features & Scope of NBN

## Institutional Network

Initially consists of six premier institutions as part of NBN:

### ICGEB
International Centre for Genetic Engineering and Biotechnology – New Delhi

### NCCS
National Centre for Cell Science – Pune

### THSTI
Translational Health Science and Technology Institute – Faridabad

### IPFT
Institute of Pesticide Formulation Technology – Haryana

### ACTREC
Advanced Centre for Treatment, Research and Education in Cancer – Mumbai

### NABI
National Agri-Food Biotechnology Institute – Punjab

# End-to-End Biomanufacturing Focus

**Design → Prototype → Test → Scale-up;** Shared infrastructure (automation, synthetic biology) allows academia, industry, startups access.

## Sectors Covered:

- Biopharma
- Bio-agriculture (bio-fertilisers, climate-smart crops)
- Bio-industrial chemicals
- Carbon capture & utilisation
- Marine & space biotechnology

## Youth & Innovation Component:

Under BioE3 Challenge for Youth ("Design Microbes, Molecules & More") – cash awards, funding up to ₹ 25 lakh for selected innovators.

# Institutional Framework & Implementation Mechanism

## Nodal Agency:

DBT (under MoS&T) as coordinating entity.

## Steering & Governance:

MoS&T Minister oversees, DBT Secretary on board; involvement of BIRAC (Biotechnology Industry Research Assistance Council) for funding and incubation.

# Registration & Collaboration

The biofoundry centres collaborate with universities, research institutes, industry and startups; provide access to equipment, design software, automated workflows.

### Funding & Infrastructure

Shared infrastructure funding, pilot scale manufacturing facilities, regulatory and safety frameworks for biomanufacturing.

### Performance Metrics

No precise national number of facilities yet published (early stage) — goal is nationwide biofoundry network building.

# Significance, Targets & Data

| $300B | $165.7B | $10B |
|---|---|---|
| Bioeconomy Target | Current Value | Starting Point |
| by 2030 | in 2024 | in 2014 |

## Significance:

- Reduces import-dependency in biotech (APIs, enzymes, biomaterials).
- Boosts startups & employment in biotechnology sector.
- Supports India's climate-smart agriculture, bio-circular economy and net-zero goals.

# Linked Schemes & Policy Context

| Scheme / Policy | Nodal Ministry | Connection with NBN |
|---|---|---|
| BioE3 Policy (2024) – "Biotechnology for Economy, Environment & Employment" | MoS&T | Umbrella policy under which NBN is launched. |
| National Biopharma Mission | MoS&T / Dept. of Biotechnology | Biomanufacturing thrust overlapping with NBN. |
| Make in India (Biotechnology sector) | Ministry of Commerce & Industry | NBN supports indigenous manufacturing. |
| National Mission on Bioeconomy | MoS&T / Dept. of Biotechnology | Strengthens pipeline from research to commercial biotech. |


# BioE3 Policy (2024–2030): Biotechnology for Economy, Environment & Employment

## Introduction

# What is BioE3 Policy

**Full Name:** National Biotechnology Policy – BioE3 (Biotechnology for Economy, Environment, and Employment).

**Launched by:** Department of Biotechnology (DBT), under the Ministry of Science & Technology (MoS&T).

**Official Launch:** 27 August 2025 (New Delhi).

**Announced by:** Dr. Jitendra Singh, Minister of State (Independent Charge), MoS&T.

**Aim:** To make India a global bioeconomy leader by integrating biotechnology into economic growth, environmental sustainability, and employment generation.

**Slogan:** "From Biotech Research to Bioeconomy Realization."

**Policy Period:** 2024–2030.

# Objectives & Vision

| Objective Area | Specific Goals (2024–2030) |
| --- | --- |
| Economy | Expand India's bioeconomy from US $165.7 billion (2024) to US $300 billion by 2030. |
| Environment | Integrate biotechnology in climate adaptation, circular economy, waste valorisation, and sustainable agriculture. |

| Objective Area | Specific Goals (2024–2030) |
|---|---|
| Employment | Create 1 crore+ direct and indirect jobs through biotechnology startups, biofoundries, and bio-manufacturing. |
| Innovation | Strengthen R&D → Commercialisation → Scale-up pipeline via initiatives like the National Biofoundry Network (NBN). |
| Governance | Establish Bioeconomy Board of India for inter-ministerial coordination. |

# Institutional Framework & Key Stakeholders

| Institution / Body | Role in Implementation |
| --- | --- |
| Ministry of Science & Technology (MoS&T) | Apex policymaking and coordination ministry. |
| Department of Biotechnology (DBT) | Nodal department managing BioE3 missions, NBN, funding schemes. |
| BIRAC (Biotechnology Industry Research Assistance Council) | |

| Institution / Body | Role in Implementation |
| --- | --- |
| BIRAC (continued) | Implements industry–academia collaboration, biotech startup grants, and bio-incubation. |
| Biotech Centres of Excellence | 20+ research institutes and bio-innovation hubs linked under BioE3. |
| Bioeconomy Board of India (proposed) | Inter-ministerial body for cross-sector convergence (health, agri, energy, environment). |
| State Biotech Missions | States like Karnataka, Telangana, Maharashtra, Tamil Nadu to align local policies with BioE3 goals. |

# Focus Sectors under BioE3

### Health Biotech

Vaccine innovation, biosimilars, gene therapy, precision medicine.

### Agriculture & Food Biotech

Climate-resilient crops, bio-fertilisers, bio-stimulants, fortified foods.

| Sector | Examples / Focus Areas |
| --- | --- |
| Industrial Biotech | Green chemistry, enzymes, bio-plastics, waste-to-value products. |
| Energy Biotech | Biofuels (2G/3G ethanol, biogas), bio-hydrogen, carbon capture technologies. |
| Environmental Biotech | Bioremediation, wastewater treatment, bio-mining. |
| Marine & Space Biotech | Exploration of oceanic microbes, space biosystems research. |

# Major Initiatives & Flagship Programmes

### National Biofoundry Network (NBN)

Core infrastructure project under BioE3 for bio-manufacturing.

### BioE3 Challenge for Youth

Innovation contest supporting young biotech entrepreneurs with up to ₹ 25 lakh.

### Bio-Circular Economy Mission

Promotes industrial biotech and waste utilisation.

### Synthetic Biology Mission

For gene editing, microbe engineering, and precision biomanufacturing.

### National Bio-Skilling Programme

Upskilling workforce in genomics, bioinformatics, and automation.

### Bio-Innovation Clusters

Regional biotech parks and hubs under DBT & BIRAC.

# Funding & Incentive Mechanism

**Estimated Investment (2025–30):** ~₹ 40,000 crore (public + private).

**Funding Channels:**

- DBT grants, BIRAC seed-funds, public-private partnership (3Ps).
- Biotech Infrastructure Fund and Bio-Innovation Fund.
- Venture capital participation via DBT's "Bio-Nest" network (75+ bio-incubators).

## Incentives:

### Tax Deduction

150 % weighted tax deduction for biotech R&D expenditure.

### Fast-track IP Filing

Fast-track IP filing under Start-up India initiative.

### Single-window Clearances

Single-window clearances for biotech testing facilities.

# Policy Integration & Linkages

| Linked Policy / Mission | Integration Point with BioE3 |
|---|---|
| National Biopharma Mission | Drug discovery & bio-manufacturing pipeline. |
| Atmanirbhar Bharat | Reduces biotech imports (APIs, biologics). |
| National Mission on Bioeconomy (NE Region) | Regional biotech hubs & ethnic bio-resources. |

| Linked Policy / Mission | Integration Point with BioE3 |
|---|---|
| Make in India | Encourages indigenous biotech equipment production. |
| Startup India / Digital India | Promotes bio-entrepreneurship and digitised biomanufacturing. |
| Paris Agreement / SDG 12, 13, 15 | Supports sustainable production & climate resilience. |

# Challenges & Strategic Outlook


## Challenges:

- High cost of biomanufacturing infrastructure.
- Regulatory & bio-safety approvals need streamlining.
- Shortage of skilled bio-engineers and technicians.
- Ethical and biosafety concerns around synthetic biology.
- Global competition in biopharma and industrial biotech domains.

## Strategic Way Forward:

01

Establish regional biofoundries and bio-innovation parks.

02

Foster industry–academia–startup partnerships.

03

Build bio-export ecosystem to achieve bioeconomy targets.

04

Strengthen biosafety regulations and IPR frameworks.

05

Collaborate with global biofoundry networks (EU, US, Japan).

# Acronyms & Key Data

| 1 | 2 |
|---|---|
| Acronyms | Key Terms |
| **BioE3:** Biotechnology for Economy, Environment & Employment | **NBN:** National Biofoundry Network |
| **MoS&T:** Ministry of Science & Technology | **Bio-Nest:** Bio-Incubator Network under BIRAC |
| **DBT:** Department of Biotechnology | **API:** Active Pharmaceutical Ingredient |
| **BIRAC:** Biotechnology Industry Research Assistance Council | **Bio-Circular Economy:** Closed-loop production using biological resources |
| | **Synthetic Biology:** Engineering biology for novel products and materials |

# Nobel Prize in Chemistry 2025

# THE NOBEL PRIZE IN CHEMISTRY 2025



# Introduction & Winners

**Awarded by:** The Royal Swedish Academy of Sciences on 8 October 2025.

**Laureates (equal parts):**

- Susumu Kitagawa (Japan)
- Richard Robson (UK/Australia)
- Omar M. Yaghi (USA)

**Reason:** For the development of metal–organic frameworks (MOFs) — a new form of molecular architecture with large cavities and tailored properties.

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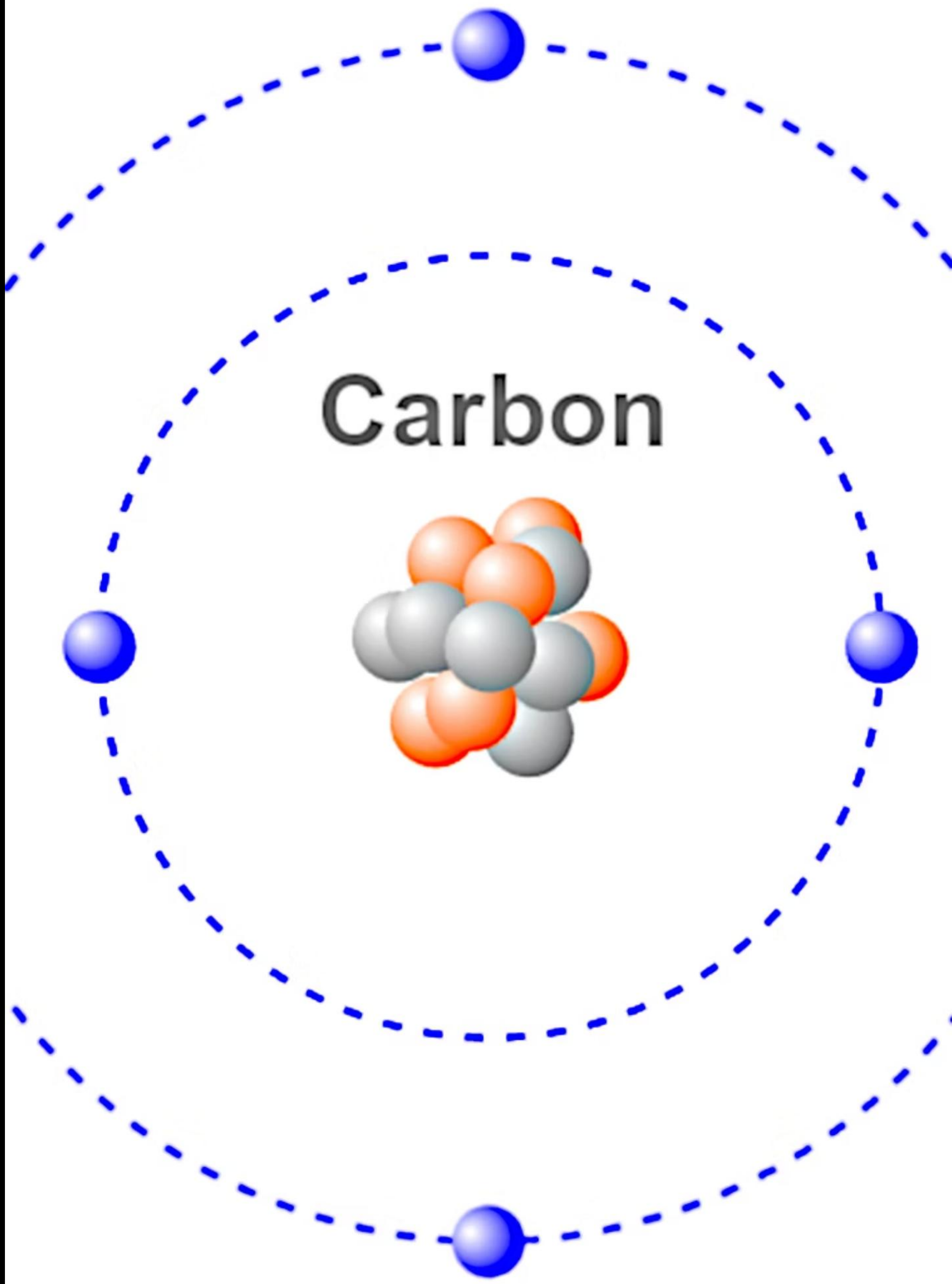
# Key applications / significance:

- Gas capture and storage (e.g., $CO_2$, $H_2$), chemical separation, catalysis.
- Water harvesting from desert air, toxic-gas storage, and design of custom materials with new functions.

Historical context: Robson's early work in 1989, Kitagawa's demonstration of flow and flexibility, Yaghi's refinement and modular design.



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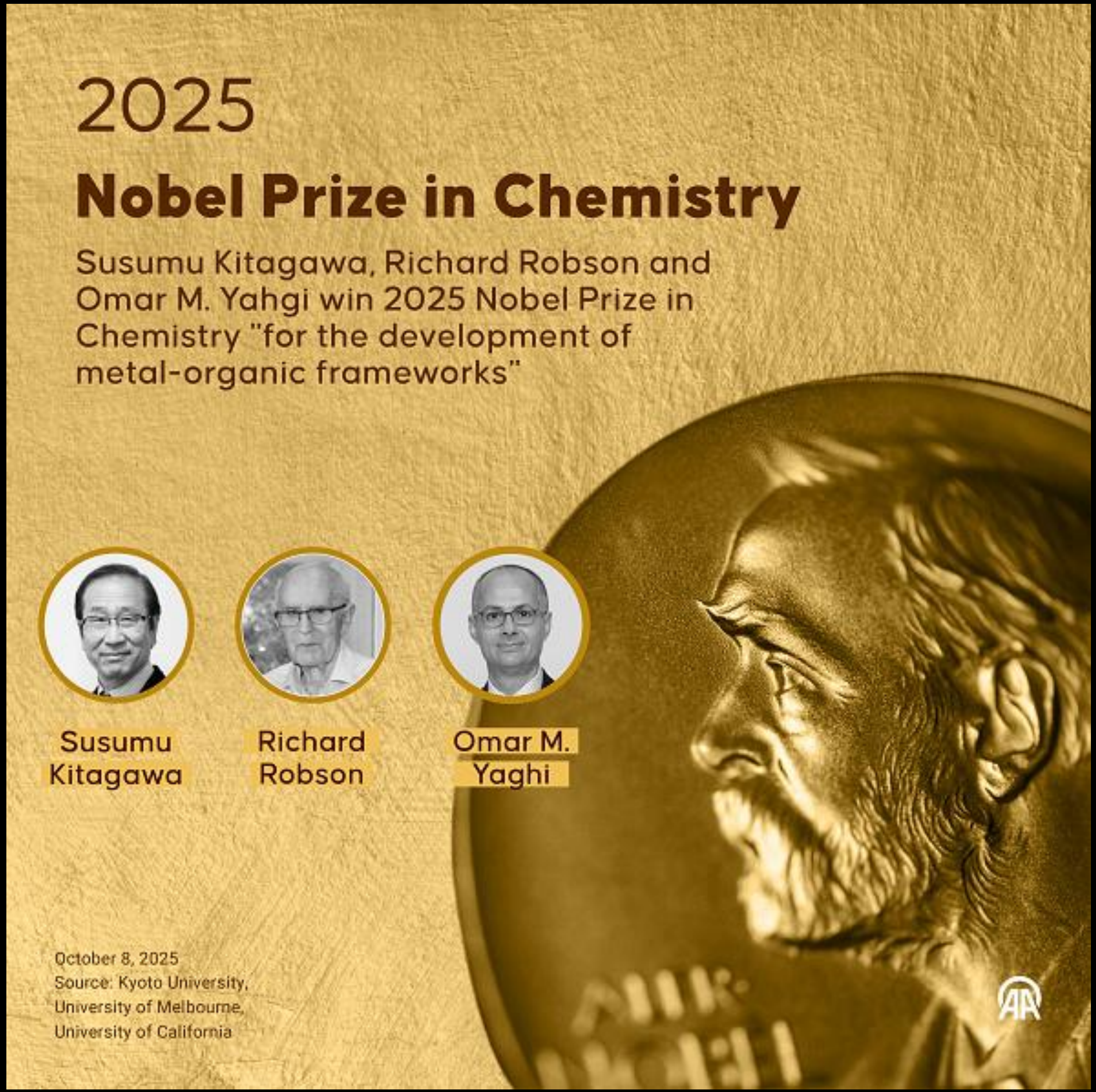
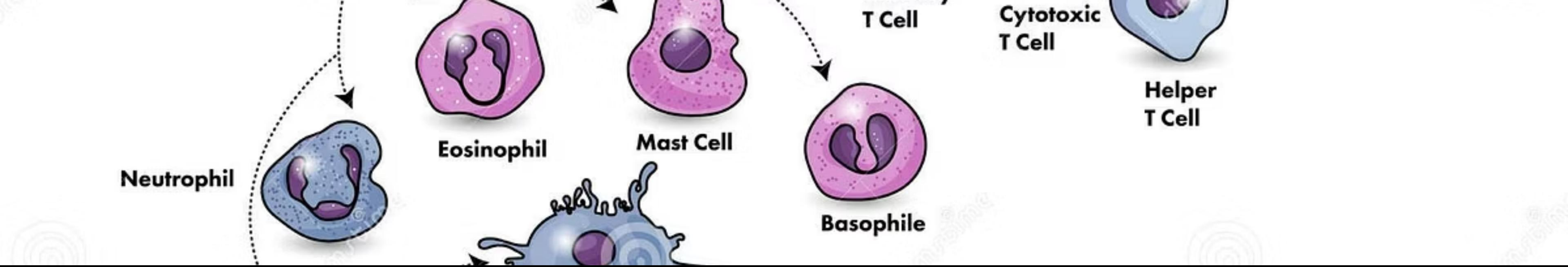
# Broader Implications

The prize highlights how fundamental materials research (architecture of molecules) can enable large-scale applications (energy, environment).






# Nobel Prize in Physiology or Medicine 2025

# Introduction & Winners

**Awarded by:** The Nobel Assembly at the Karolinska Institute on 6 October 2025.

**Laureates (equal shares):**

- Mary E. Brunkow (USA)
- Fred Ramsdell (USA)
- Shimon Sakaguchi (Japan)

**Reason:** For their discoveries concerning peripheral immune tolerance, especially regulating how the immune system avoids attacking the body's own tissues.

# Core Discovery – Immune Tolerance & Regulatory T Cells

**Immune system basics:** The body must defend against microbes/invaders, but must also not attack its own cells (self-tolerance).

## Central vs Peripheral Immune Tolerance:

- Central tolerance occurs in the thymus during T cell development; problematic cells eliminated.
- Peripheral tolerance occurs outside the thymus and involves mechanisms that regulate mature immune cells. Sakaguchi's work showed regulatory T cells (Tregs) do this crucial role.

# Critical Minerals

## Introduction & Definition

**Term:** Critical minerals (also called critical raw materials, strategic minerals)

**Definition:** Minerals that are essential for a country's economic development, defence, energy transition, technology and have supply-chain risks (scarcity, geopolitics, import dependence).

## Why now in news?

- Surge in demand due to green energy transition (EVs, batteries, renewables).
- Concentrated supply chains (few countries dominate mining/processing).
- Geopolitical and security dimensions (export controls, trade restrictions).

# Key Minerals & Their Roles

**Some common critical minerals:** Lithium, Cobalt, Nickel, Graphite, Rare Earth Elements (REEs), Copper, Vanadium, Titanium, Tungsten, Zirconium etc.

## Examples of uses:

### EV Batteries & Energy Storage

Lithium / Nickel / Cobalt / Graphite → EV batteries, energy storage

### Advanced Technology

REEs → Permanent magnets, wind turbines, electronics, defence systems

### Power Infrastructure

Copper → Power transmission grid, renewables, EV charging infrastructure

**Supply chain stages:** Mining → Concentrate → Refining/Processing → Manufacturing → Recycling.

# Global Supply & Concentration Facts

China dominates rare earth mining and processing (≈70 % of mining, ≈90 %+ of global processing).

The European Union's **Critical Raw Materials Act (CRM Act)** (since May 2024) aims to secure supply of critical raw materials.

India's source: In 2023, Ministry of Mines (India) released a list of 30 critical minerals for India.

# Demand Drivers & Strategic Importance

### Green Energy Transition

Renewables, EVs, grid storage increase mineral intensity.

### Technology & Defence

Advanced electronics, aerospace, military hardware rely on specialised minerals.

### Energy Security & Supply Chains

Countries realise import dependence for these minerals presents strategic vulnerability.

# India's Position & Mission

## Critical Mineral Mission

India's critical mineral mission: The Ministry of Mines outlined strategy; India has release of 30 critical minerals list.

India's import dependency high for many minerals (e.g., lithium, cobalt, nickel) despite domestic reserves.

## Global Outreach

India's outreach: MoUs with Australia, Argentina, Democratic Republic of Congo etc to secure supply chains.

# Geopolitics & Supply Chain Risks

Strong supply-chain concentration → export controls as a geopolitical tool (e.g., China restricting exports of rare earths).

Global alliances: e.g., Minerals Security Partnership (MSP) includes India and US, aims to diversify supply chains.

Recent news: Countries warning of disruptions if supply chains are not diversified.

# Critical Minerals in Semiconductors & AI Technologies

## 1 Role in Chip Manufacturing

Semiconductors — the "brains" of modern electronics — rely heavily on specific high-purity minerals and metals at various stages of fabrication.

# Mineral Roles in Chip Manufacturing

| Mineral / Element | Role in Chip Manufacturing |
|---|---|
| Silicon (Si) | Base material for most semiconductors (substrate). |
| Gallium (Ga) | Used in Gallium Nitride (GaN) and Gallium Arsenide (GaAs) chips → high-frequency, high-efficiency devices (5G, satellite comms). |
| Germanium (Ge) | Semiconductor doping and fiber optics. |
| Indium (In) | Used in Indium Tin Oxide (ITO) coatings for displays, photonics, and transistors. |
| Cobalt (Co), Nickel (Ni), Tantalum (Ta) | Integral in chip interconnects, capacitors, and plating materials. |
| Rare Earth Elements (REEs) | Used in polishing wafers, lasers, magnets, and lithography components. |
| Copper (Cu), Tungsten (W) | Key for interconnects and contact layers inside integrated circuits. |

# Linkage to GPUs & AI Hardware



GPUs (Graphics Processing Units) — essential for AI model training and inference — are made using advanced semiconductor materials and rely on high-performance rare elements.

## Key Dependencies:

- Gallium, Indium, Rare Earths → used in high-frequency power amplifiers and optical interconnects.
- Cobalt, Nickel, Graphite → critical for AI data-center battery backup systems and energy storage units.
- Copper, Aluminium, Silver → thermal management and high-conductivity wiring for GPUs.
- Silicon Carbide (SiC) → used in AI and EV power electronics due to higher efficiency and heat tolerance.

**Fact:** Each NVIDIA A100/H100 or AMD MI300 GPU has a materials footprint including over 20 critical minerals across its silicon die, PCB, cooling, and power supply components.

# 3 Global Geopolitical Context

**China's dominance:** China controls ~60 % of gallium and ~80 % of germanium supply globally — both vital for chips and optical electronics.

**July 2023 Export Controls:** China restricted export of gallium and germanium, citing "national security," escalating tech tensions.

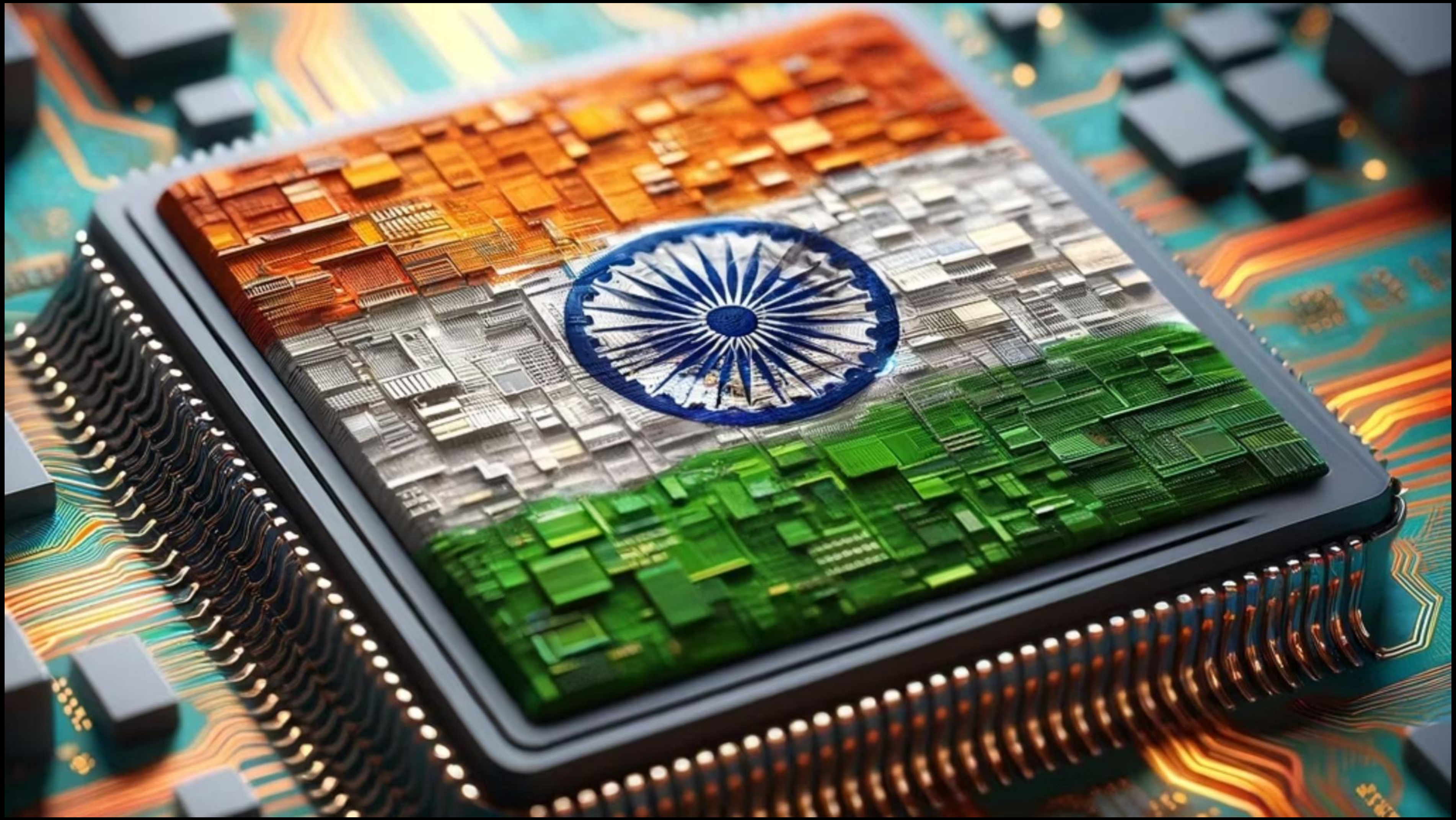
**U.S. CHIPS and Science Act (2022) + EU Chips Act (2023):** Both include funding for securing critical minerals to reduce dependency on external sources.

## India's Role:

1. India included Gallium, Germanium, Graphite, Cobalt in its 2023 List of 30 Critical Minerals (Ministry of Mines).

2. India joined Minerals Security Partnership (MSP) to secure semiconductor-related supply chains.

# India's Strategy for Critical Minerals in Semiconductor Supply Chains



# Nodal Ministries & Agencies

### Ministry of Mines

Release of "30 Critical Minerals" list (March 2023) including gallium, germanium, cobalt, graphite.

### Ministry of Electronics and Information Technology (MeitY)

Leads semiconductor incentive schemes (e.g., PLI for semiconductors) and works to secure raw-material supply chains.

### Geological Survey of India (GSI)

Mapping and exploration of critical-mineral reserves domestically.

# Key Policy Measures & Domestic Production

## Key Policy Measures:

- Fiscal incentives for mining and processing of critical minerals under the "National Critical Minerals Mission" (proposed).
- Bilateral MoUs with countries like Australia, Argentina, Chile, DRC for cobalt/lithium/germanium sourcing.
- Production-Linked Incentives (PLI) for semiconductor manufacturing include raw-material support from Mines & MeitY.

## Domestic Production Initiatives:

- Discovery of high-grade germanium ore deposits in East India belt (2024).
- Launch of "Rare-Earth Processing Plant" project in Odisha for value-addition to monazite sands and extraction of REEs used in semiconductor lithography.

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# International Partnerships & Supply-chain Diversification

## Key Multilateral Initiatives:

**Minerals Security Partnership (MSP)** — India, US, Japan, Australia, EU partner to ensure diversified critical-mineral supply chains for high-tech and defence sectors.

**Critical Raw Materials Act (European Union, 2023)** — Sets target of sourcing 10 % of EU's annual consumption of critical raw materials from domestic or allied sources by 2030.

# Bilateral Agreements & Risk Mitigation

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## Bilateral Agreements:

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### India-Australia Critical Minerals Roadmap (2024)

Focus on rare earths, cobalt and lithium for EV/AI hardware.

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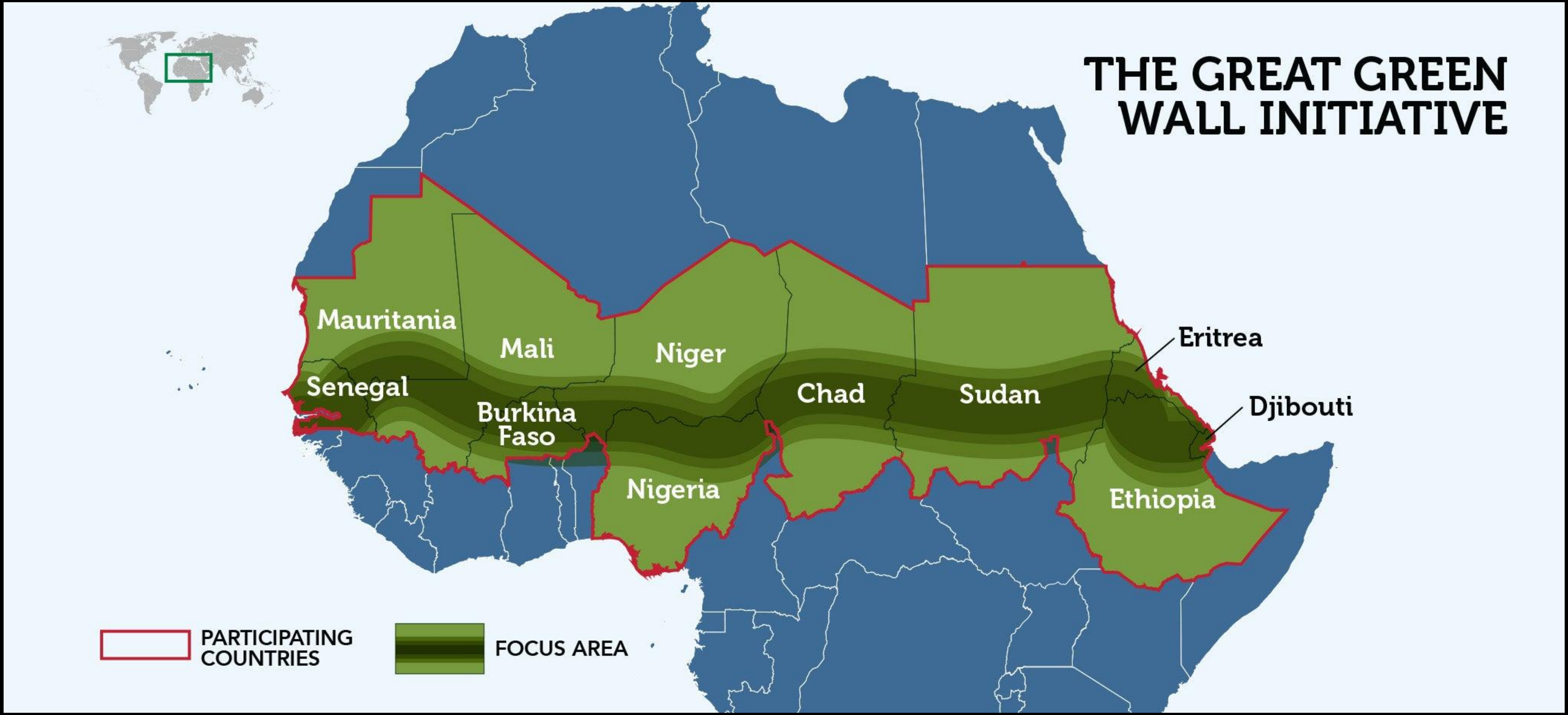
### India-Chile Mines Cooperation MoU (July 2025)

Chile supplies high-purity copper and germanium/chalcogenide compounds for Indian semiconductor fabs.

## Supply-chain Risks & Mitigation:

- Awareness that ≥60 % of global processing of gallium/germanium occurs in one country → India aims to develop processing capacity to avoid bottlenecks.
- Emphasis on recycling of critical minerals from e-waste and used-GPU stockpiles to reduce import dependence.

# Great Green Wall Initiative



# Introduction & Background

The **Great Green Wall Initiative (GGWI)** is a flagship African-led program adopted by the African Union (AU) in 2007 to combat desertification, land degradation and promote ecosystem restoration across the Sahel and Sahara belt.

The initiative envisions creating a broad "wall" of greenery stretching across Africa — originally envisaged at up to **~8,000 km** from Dakar (Senegal) to Djibouti (Horn of Africa).

**Key target timeline:** by 2030, restore 100 million hectares of degraded land, sequester 250 million tonnes of carbon, and create 10 million green jobs in the participating regions.

# Objectives, Scope & Participating Countries

## Objectives:

- Restore degraded landscapes and soils in the Sahel-Sahara region.
- Improve food security, create sustainable livelihoods and reduce forced migration from desertifying zones.
- Enhance climate resilience, biodiversity conservation and carbon sequestration through green infrastructure.

# Scope & Geography:

| 1 | 2 |
|---|---|
| **Countries Involved**<br>Involves more than **20 African countries**; 11 core countries in the front-line Sahel belt including Burkina Faso, Chad, Djibouti, Eritrea, Ethiopia, Mali, Mauritania, Niger, Nigeria, Senegal and Sudan. | **Project Evolution**<br>The project has evolved into a **"mosaic of green and productive landscapes"**, not just a literal "wall". |

# Implementation Mechanisms & Partnerships

The initiative is coordinated by the **Pan-African Agency of the Great Green Wall (PAGGW)** under the AU-framework, in collaboration with regional bodies, national governments, local communities and international partners (EU, UNCCD, World Bank, African Development Bank).

**Key mechanism:** "Integrated Landscape Approach" — combining agro-forestry, grazing land management, water harvesting, community engagement, and tree planting.

**Funding commitments:** Billions of USD pledged by international donors under programmes such as the "Great Green Wall Accelerator" (2021) to step up implementation.

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# Samudrayaan Project

# Introduction & Mission Overview

- **Name:** Samudrayaan Project
- It is part of the **Deep Ocean Mission (DOM)** under the Ministry of Earth Sciences (MoES), Government of India.
- **Objective:** To send a manned submersible to a depth of 6,000 metres in the Indian Ocean to explore deep-sea resources and technologies.
- **Key vehicle:** MATSYA-6000 — a deep-sea crewed vehicle developed under the mission.
- **Timeline:** The Deep Ocean Mission (2021-26) is the overarching programme; Samudrayaan is a key component.

# Key Technical Features & Scope

The personnel sphere of **MATSYA-6000:** diameter ~2.26 m, wall thickness ~80 mm titanium alloy (Ti6Al4V-ELI grade), withstanding ~600 bar pressure at deep-sea conditions.

**Crew:** Designed to carry three humans (aquanauts) for ~12 hours operation; emergency endurance up to ~96 hours.

## Key mission goals:

- Develop deep-sea mining technologies (polymetallic nodules — nickel, cobalt, copper, manganese) in the Central Indian Ocean Basin.
- Study deep-sea biodiversity, ocean climate change advisory services, fresh-water/energy from ocean, advanced marine station.

**Technology collaborations:** The personnel sphere is being developed by Vikram Sarabhai Space Centre (VSSC) in collaboration with National Institute of Ocean Technology (NIOT).

# Related Static & Conceptual Facts

**Nodal Ministry:** Ministry of Earth Sciences (MoES), Government of India.

## Related Concepts:

### Blue Economy

Sustainable use of ocean resources for economic growth, improved livelihoods, and ocean ecosystem health.

### Exclusive Economic Zone (EEZ)

Under the United Nations Convention on the Law of the Sea (UNCLOS), India has rights over its EEZ (200 nmi) and continental shelf; the project builds on India's seabed exploration rights.

### Polymetallic nodules

Mineral deposits found on seabed (e.g., in Central Indian Ocean Basin) containing nickel, cobalt, manganese, copper – key to deep-sea mining ambitions.

# Thank You!

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