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UPSC CSE MAINS

GEOGRAPHY OPTIONAL

PAPER II

Transport, Communication and Trade Notes

The complete Transport, Communication and Trade section of Paper II — road, rail, air and pipeline networks, ports and waterways, trade balance and policy, export processing zones, communication and the space programme, with previous year questions.

Compiled by Arvind KrS

ROAD AND RAIL

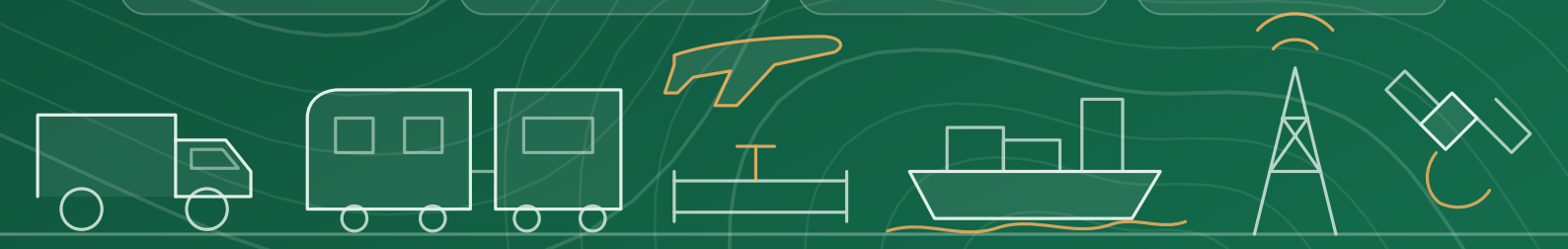
PORTS AND WATERWAYS

AIRWAYS AND PIPELINES

TRADE

COMMUNICATION AND SPACE

13	4	81	58
Chapters	Units	Previous year questions	Diagrams and figures



IN THIS BOOK

01 Transport Networks

02 Ports and Waterways

03 Trade

04 Communication and Space

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Geography Optional — Transport, Communication and Trade

Paper II · Geography of India: Transport, Communication and Trade

Mains 2027 Edition · Compiled November 2026

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Questions or corrections: support@lotusarise.com

The outline map of India on the cover and on the chapter and unit pages is decorative and not to scale.

How to read these notes

Every chapter is marked against the questions UPSC has actually asked on it, so the points that matter most stand out on the first read and are quick to find at revision.

Inland water transport runs on rivers, canals and lakes.

Yellow marker: key point. A point that carries the ideas UPSC has asked about in this chapter. Read these first, and make sure each one is in your answer.

Water transport is the cheapest and the oldest mode of transport.

Blue marker: definition. The cleanest definition of a term, ready to open an answer with.

It works on **national waterways**, which Parliament declares by law.

Saffron underline: PYQ term. A key term or phrase that appears in this chapter's previous year questions.

Inland Waterways PYQ 1996 · 1989

PYQ tag on a heading. The years in which UPSC asked about this section. Sections without a tag are background or linking material.

PYQ RADAR **5** questions Last asked **2026**

PYQ radar. At the start of each chapter: how many times the topic has been asked, and how recently. The contents page shows the same count for every chapter.

Suggested method. First read: the whole chapter. Revision: the yellow and blue marks, the tagged headings and the PYQ list at the end of the chapter. Last week before Mains: the PYQ list alone, answering each question in your head from the marked points.

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UNIT 02
4 CHAPTERS

Ports and Waterways

Waterway networks; growing importance of ports on national and foreign trade.



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GEOGRAPHY OPTIONAL

PAPER II · TRANSPORT, COMMUNICATION AND TRADE

Growing Importance of Ports and the Sagarmala Project



PYQ RADAR **5** questions Last asked **2025** 2025 · 2024 · 2017 ×2 · 2003

CONTENTS

01 Growing Importance of Ports
02 The Sagarmala Project
03 Previous Year Questions

- **Ports** are the point where India's foreign trade, its coastal economy and its inland transport meet. Nearly all of the country's trade by volume passes through them.
- The **Sagarmala Programme**, launched in **March 2015**, is the national plan for **port-led development**: it treats a port as the base for connectivity, industry and coastal livelihoods, not only as a place to load ships.

01 Growing Importance of Ports PYQ 2003

Ports in National and Foreign Trade PYQ 2003

- The coast: India's **coastline**, long given as **7,516.6 km** and split as 6,100 km of mainland coast plus the Andaman, Nicobar and Lakshadweep islands, was re-assessed in 2025 at **11,098.81 km**.
  - It touches **13 States and Union Territories**. The **western coastal plains** lie along the Arabian Sea and the **eastern coastal plains** along the Bay of Bengal.
  - **20% of India's population** lives in coastal areas.
- Coastal economy: the maritime States contribute about **60% of India's GDP**. Big and small ports along the coast carry out their trade.
- Number of ports: the long-used count is **13 major and 200 minor ports**, of which **60 non-major ports were operational**, on a coast of **over 7,500 km**.
  - The current count is **12 operational major ports**, two more under construction, and **over 200 non-major ports**.

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- Share of trade: 95% of India's foreign trade by volume and 70% by value moves by sea, a figure also given as **90% by volume and 70% by value**.
- Traffic: major ports were said to handle about **58%** of cargo. By 2024-25 the share stood at **53.5%** of **1,597.27 million tonnes**, as non-major ports grew faster.
- **Cargo at major ports:** the older split was **bulk 44%** (iron ore, coal and fertiliser), **liquid 33%** (petrol, oil and lubricants) and **container 23%**.
  - In 2025-26, petroleum products made up 29.77%, containers 23.29% and coal 21.03%.
- Why water matters: water transport has served the Indian economy **since time immemorial**. It is an **easy, cheap and energy-efficient** way to export and import heavy goods, and ports are the essential link in it.
- Internal trade: besides foreign trade, ports serve **internal trade**. Many rivers link with major ports, and they carry goods between port and **hinterland**. Coastal cargo was **23.33%** of major-port traffic in 2025-26.

Why Some Ports Grew First

- Of India's sea-borne trade, **more than 85%** was once shared by Bombay, Calcutta, Cochin, Madras and Visakhapatnam, for both geographical and historical reasons.
- **Mumbai, Chennai and Kolkata** were **centres of administration** for a long time.
  - As their populations grew, **commercial and industrial activity** grew too.
  - **Railway lines** were built to them in the later half of the 19th century, and they turned **from political centres into great ports**.
- The pattern has since shifted north-west and to deep-water bulk ports. In 2025-26, the top five major ports were Deendayal, Paradip, Jawaharlal Nehru, Visakhapatnam and Mumbai, with **63.94%** of major-port cargo, while **Gujarat's non-major ports** carried about 65% of non-major traffic.

Seaports and Regional Development PYQ 2024

- Port to hinterland: a port grows with its hinterland, and the hinterland in turn grows with its port.
  - **Mumbai's** rise drew on the cotton and industry of western India.
  - **Kolkata** serves the whole east and north-east, along with **Nepal and Bhutan**.
- Port-based industry: imported or exported bulk cargo pulls heavy industry to the coast.
  - **Haldia** has a refinery, fertiliser and petrochemical plants.
  - **Port-led sites** such as Mundra and Visakhapatnam draw steel, power and refining.
  - **Kandla** gave India its first export processing zone (1965).
- Regional balance: new ports can lift backward coasts. **Paradip** opened Odisha's minerals to the sea, and **New Mangalore** served the iron ore of Karnataka.
- Limits: the benefit stays near the coast unless rail and road reach inland, and a small hinterland limits ports such as Mormugao. Coastal regions can gain income while fishing communities bear the losses.
- A corridor view: the **Western Dedicated Freight Corridor**, completed to JNPT in March 2026, and coastal corridors extend a port's reach far inland.

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02 The Sagarmala Project PYQ 2025 · 2017

Rationale for Sagarmala Project PYQ 2025

- The Sagarmala project promotes **port-led direct and indirect development** and provides infrastructure to move goods to and from ports quickly, efficiently and cost-effectively.
- **No cohesive institutional arrangement:** many agencies are involved in coastal infrastructure, which causes **policy failure and ambiguity** in carrying out projects.
- **Weak infrastructure at ports and beyond:** limited mechanisation, lack of scale and deep draft, and poor facilities at many ports hold back port-led development.
- **Lack of requisite infrastructure:** moving goods from major and non-major ports to the hinterland suffers from a shortage of **modal and multimodal transport**.
- **Limited hinterland linkages:** these gaps raise the **cost of transport and cargo movement** and limit the linkages coastal regions need.
- **Limited centres of manufacturing** and economic activity in the hinterland also called for an **integrated project**.

Objectives of Sagarmala Project PYQ 2025

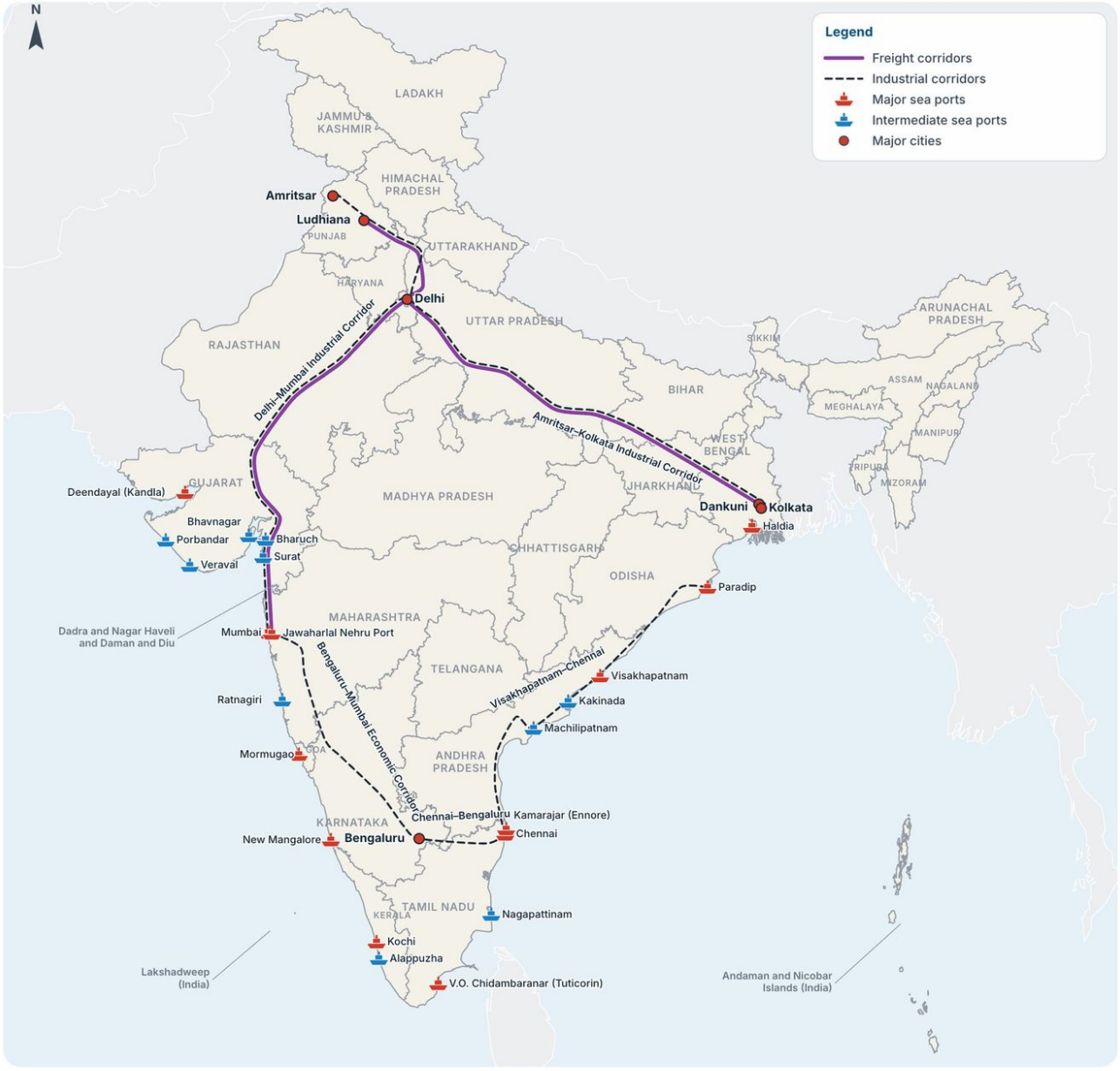
- **Port-led development:** the development of **Coastal Economic Zones**, with projects for port-based industrialisation, coastal tourism, logistics parks, warehousing, fisheries and so on.
- **Port infrastructure enhancement:** turning existing ports into **world-class ports** through deep drafts, mechanisation of existing berths, and new capacity and **greenfield ports**.
- **Efficient evacuation:** expanding the **rail, road and inland waterway networks** linked to ports, and identifying congested routes.

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TRANSPORT · PORTS

Sagarmala Network, 2015

The freight and industrial corridors that port traffic would join, with some of the major and intermediate ports.



Schematic: routes are generalised. Not to scale. Boundaries: Survey of India outline (datameet).

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- This map dates from 2015 and shows the **freight and industrial corridors** that port traffic would join, with some of the ports.

Sagarmala Vision

- Sagarmala aims to open access to new development regions through **intermodal solutions**, promote the **best modal split**, and improve links with main economic centres through wider rail, inland water, coastal and road services.

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- **Changing the way India moves logistically:**
  - Raise the competitiveness of core industry and manufacturing by saving up to 5% of the input cost of power and steel through modern port infrastructure.
  - Use national resources better by raising trade on inland waterways and coastal shipping by 50 million tonnes a year (MTPA).
  - Use an **IT-enabled national multimodal logistics plan** to streamline the project.
  - Build **coastal roads** through the maritime States, linking them with at least **two-lane highways**.
- **Creating world-class port institutions:**
  - **Sagarmala Development Company Limited (SDCL)** was incorporated on **31 August 2016** under the **Companies Act, 2013**. Its objectives were to:
    - Develop and formulate projects arising from the **National Perspective Plan (NPP)**.
    - Assist project **special purpose vehicles (SPVs)** set up by Central line ministries, State Governments, State Maritime Boards, ports and others, for projects in line with Sagarmala.
    - Provide a **funding window for residual projects** that no other source could fund.
    - Prepare the **Detailed Master Plans** for the Coastal Economic Zones (CEZs) identified in the National Perspective Plan.
    - Raise funds from **multilateral and bilateral agencies** as long-term debt or equity, as projects required.
  - In **June 2025** the company became **Sagarmala Finance Corporation Limited**, India's first non-banking financial company (NBFC) for the maritime sector.
  - **Sagarmala Coordination and Steering Committee (SCSC):**
    - At the national level, this committee sits under the **Cabinet Secretary**. Members are the Secretaries of Shipping, Road Transport and Highways, Tourism, Defence, Home Affairs, and Environment, Forest and Climate Change; the Departments of Revenue, Expenditure, and Industrial Policy and Promotion; the Chairman of the Railway Board; and the CEO of NITI Aayog.
    - It **coordinates ministries, State Governments and agencies**, and reviews progress on the National Perspective Plan, the Detailed Master Plans and individual projects.
  - Other bodies: the **National Sagarmala Apex Committee**, formed in May 2015, gives overall policy guidance. The **Maritime States Development Council** brings the Centre and States together, and **State Sagarmala Committees** identify and monitor projects.
  - A **world-class public-private partnership (PPP) programme** in ports, waterways and connectivity projects is meant to attract the best domestic and international investors.
  - **Maritime services clusters** will boost port infrastructure, for example through **shipbuilding** facilities.
- **Boosting development through ports and shipping:**
  - For 2–3 port-based smart cities and marine clusters or CEZs, over **10,000 acres** of land would be pooled, creating **50,000 direct jobs**.
  - Launch of **100 early-bird projects**, including PPP projects, with ₹1,00,000 crore of investment.
  - Addition of 1,200–1,500 MTPA of port capacity, by strengthening existing ports and launching **3–4 new mega ports**.
  - Establishing a **world-class transshipment port**.

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- **Empowering coastal communities:**
  - **Skill development** in coastal communities, for example in fisheries, with an early aim of **20 million jobs** in the maritime States. The programme now puts its employment potential at about 1 crore jobs, 40 lakh of them direct and 60 lakh indirect.
  - Community development from tourism on islands, at lighthouses and on cruises would raise the GDP share of the maritime States and sectors.
- The original **four pillars** have since become **five**. The fifth is **coastal shipping and inland waterways transport**, and the first now reads port modernisation and new port development.

Potential Benefits of Sagarmala Project PYQ 2025

- Under this framework the Government hoped to raise cargo traffic three-fold in the next 5 years, benefiting about **14% of the country's population** in at least **13 States and Union Territories**.
- It will integrate the **coastal economy with the ports** through **Coastal Economic Regions** and projects with synergies to **coastal industrial corridors**.
- It will lead to **port-based smart cities** and other urban infrastructure, raising standards of living.
- **Skill development and livelihood projects** will serve coastal communities.
- **Modernising and expanding existing ports** and creating **greenfield ports** will reduce bottlenecks to future growth.
- **Port evacuation** (road, rail, inland waterways) and logistics infrastructure will cut the **overall logistics cost** and increase cargo movement to and from the hinterland.
- The **maritime sector** will bring new economic activity to the region, for example **shipbuilding and repair clusters**.
- Easing **policy and institutional bottlenecks** in project approvals, funding and implementing partners will help implementation and monitoring.
- **Some other benefits:**
  - **Ease of doing business.**
  - Shorter **farm-to-factory** time for products and raw materials.
  - **Employment generation.**
  - India may become a major destination of **port-led trade** among the major economies of east and west.

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Six Mega Ports Planned Under Sagarmala Project PYQ 2025

TRANSPORT · PORTS

Six Mega Ports Planned Under Sagarmala: an Early List

The early list, by State, place and port.

State	Place	Port
Kerala	Vizhinjam	Vizhinjam International Seaport
Tamil Nadu	Colachel	Colachel Seaport
Maharashtra	Vadhavan (near Dahanu)	Vadhavan Port
Karnataka	Tadadi	Tadadi Port
Andhra Pradesh	Machilipatnam	Machilipatnam Port
West Bengal	Sagar Island	Sagar Island Port

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- This table carries an early list. The **National Perspective Plan** named Vadhavan, Enayam, Sagar Island, Paradip Outer Harbour, Sirkazhi and Belekeri. **Vizhinjam** went ahead as a State project, and Enayam stands near Colachel.
- **What became of them: Vadhavan** is under construction, and **Vizhinjam** was dedicated on 2 May 2025. The viability of **Sagar Island** came up for re-examination after West Bengal announced a port at Tajpur.

Coastal Economic Zones

- A **Coastal Economic Zone (CEZ)** is a designated coastal area with special economic rules, such as tax incentives and lower tariffs, to attract foreign direct investment.
- It resembles a **Special Economic Zone (SEZ)**, but it focuses on coastal projects: **port-proximate industrial clusters**, port-led development and lower cost and time for moving goods.
- CEZs form part of a plan for **14 such clusters** to spur manufacturing and jobs. The plan foresaw **₹15,000 crore** of investment in the first phase and **more than 1.5 lakh jobs**.
- **Coastal Economic Zones planned under Sagarmala:**

S.NO.	CEZ	STATE	LINKAGE PORTS
1	Kachchh	Gujarat	Deen Dayal, Mundra

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S.NO.	CEZ	STATE	LINKAGE PORTS
2	Saurashtra	Gujarat	Pipavav, Sikka
3	Suryapur	Gujarat	Dahej, Hazira
4	North Konkan	Maharashtra	JNPT, Mumbai
5	South Konkan	Maharashtra, Goa	Dighi, Jaigarh, Mormugao
6	Dakshin Kanara	Karnataka	New Mangalore
7	Malabar	Keralam (Kerala)	Cochin
8	Mannar	Tamil Nadu	VOCPT (Tuticorin)
9	Poompuhar	Tamil Nadu	Cuddalore
10	VCIC South	Tamil Nadu	Chennai, Kamarajar, Kattupalli
11	VCIC Central	Andhra Pradesh	Krishnapatnam
12	VCIC North	Andhra Pradesh	Vizag, Kakinada
13	Kalinga	Odisha	Paradip, Dhamra
14	Gaud	West Bengal	Kolkata, Haldia

- VCIC is the **Visakhapatnam–Chennai Industrial Corridor**. Its three zones tie the ports of the middle east coast to the **industry** inland.

Sagarmala in Practice

- **Progress at 24 March 2026:**

STATUS	PROJECTS	VALUE
Taken up	845	₹6.06 lakh crore
Completed	315	₹1.57 lakh crore
Under implementation	210	—

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STATUS	PROJECTS	VALUE
At planning stage	320	—

- Results reported:
  - **Vessel turnaround** fell from **96 hours (2014) to 49.5 hours (2025)**.
  - Major ports handled about **915 million tonnes** in 2025-26, and **inland waterway cargo** rose from 18.1 million tonnes (2013-14) to 145.5 (2024-25) and 218 (2025-26).
  - **Eleven fishing harbours** were completed, and **7 coastal berths** added 9.84 MTPA.
  - **Ghogha–Hazira Ro-Pax** cut about 10 hours by road to 4 by sea, and **Mumbai–Mandwa** replaced a 109 km road journey with 18.5 km by sea.
- **Sagarmala 2.0:** proposed with **₹85,482 crore** of budget support and **₹3.6 lakh crore** of total investment, tied to the **Maritime India Vision 2030** and **Maritime Amrit Kaal Vision 2047**.
- Critical view:
  - Pace: after eleven years, completed projects are about a quarter of the programme by value, and 320 are still at the planning stage.
  - **Coastal communities:** the **National Fishworkers' Forum** and other groups have opposed the programme on grounds of **displacement, coastal erosion and thin consultation**, and fishers opposed the port at Vizhinjam.
  - Environment: deep-water ports and dredging raise concerns in fragile coastal tracts, and changes in **coastal regulation** rules have drawn objections.
  - **Dependence on one route:** the programme improves links to sea trade but does not by itself reduce exposure to **maritime choke-points**.

Previous Year Questions

2025	With reference to the transport and communication network of India, critically discuss the 'Sagarmala project'.
2024	Examine the relationship between seaports and regional development in India.
2017	Describe the salient features of the Sagar Mala Project and highlight its role in port-led development of coastal regions in India.
2003	Discuss the growing importance of ports in foreign trade of India.

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2017 Describe the salient features of Sagar Mala Project and highlight its role in port-led development of coastal regions in India.

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UNIT 04 | 2 CHAPTERS

Communication and Space

Developments in communication and information technology and their impacts on economy and society; Indian space programme.



CHAPTERS

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PAPER II · TRANSPORT, COMMUNICATION AND TRADE

Indian Space Programme



PYQ RADAR **11** questions Last asked **2025** 2025 · 2024 ×2 · 2023 · 2022 ×2 · 2020 · 2019 · 2017 ×3

CONTENTS

01 Organisation and Objectives
02 Launch Vehicles
03 Satellites and Their Applications
04 Important Milestones
05 Science, Exploration and Crewed Flight
06 Policy and the Private Sector
07 Previous Year Questions

- The **Indian space programme** applies rockets and satellites to **national development**, and it has grown from a sounding rocket at Thumba in 1963 to lunar landings and a private orbital launch in 2026.
- It reads well through a **possibilistic approach**: technology widens the choices open to a society within the limits set by its environment.
- It is a **tool for regional development**, since satellites reach remote, hilly and island areas that ground networks serve poorly.
- Its services work alongside the **optical fibre and wireless systems** of the **communication network**.
- It forms part of India's wider **science and technology** effort, with ISRO as one of its leading institutions.

01 Organisation and Objectives

Objectives of the Indian Space Programme PYQ 2019

- The **Indian Space Research Organisation (ISRO)** is the **nodal agency and flag bearer** of the programme, under the **Department of Space (DoS)**.
  - Beyond building and launching missions and launch vehicles, ISRO offers a wide range of services and supports science and science education.
  - Research centres and autonomous institutions in remote sensing, astronomy and astrophysics, atmospheric sciences and space sciences function under the Department.

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- The **objectives are twofold**:
  - **Space discovery and exploration** through missions.
  - **Promotion of research and education** in space science, for example tele-education in remote areas.
- Other functions:
  - **Resource management**, covering minerals, agriculture and marine resources.
  - Environment conservation.
  - Internal security and counter-terrorism, for example the use of IRNSS for regional security.
  - Weather forecasting.
  - Disaster management.

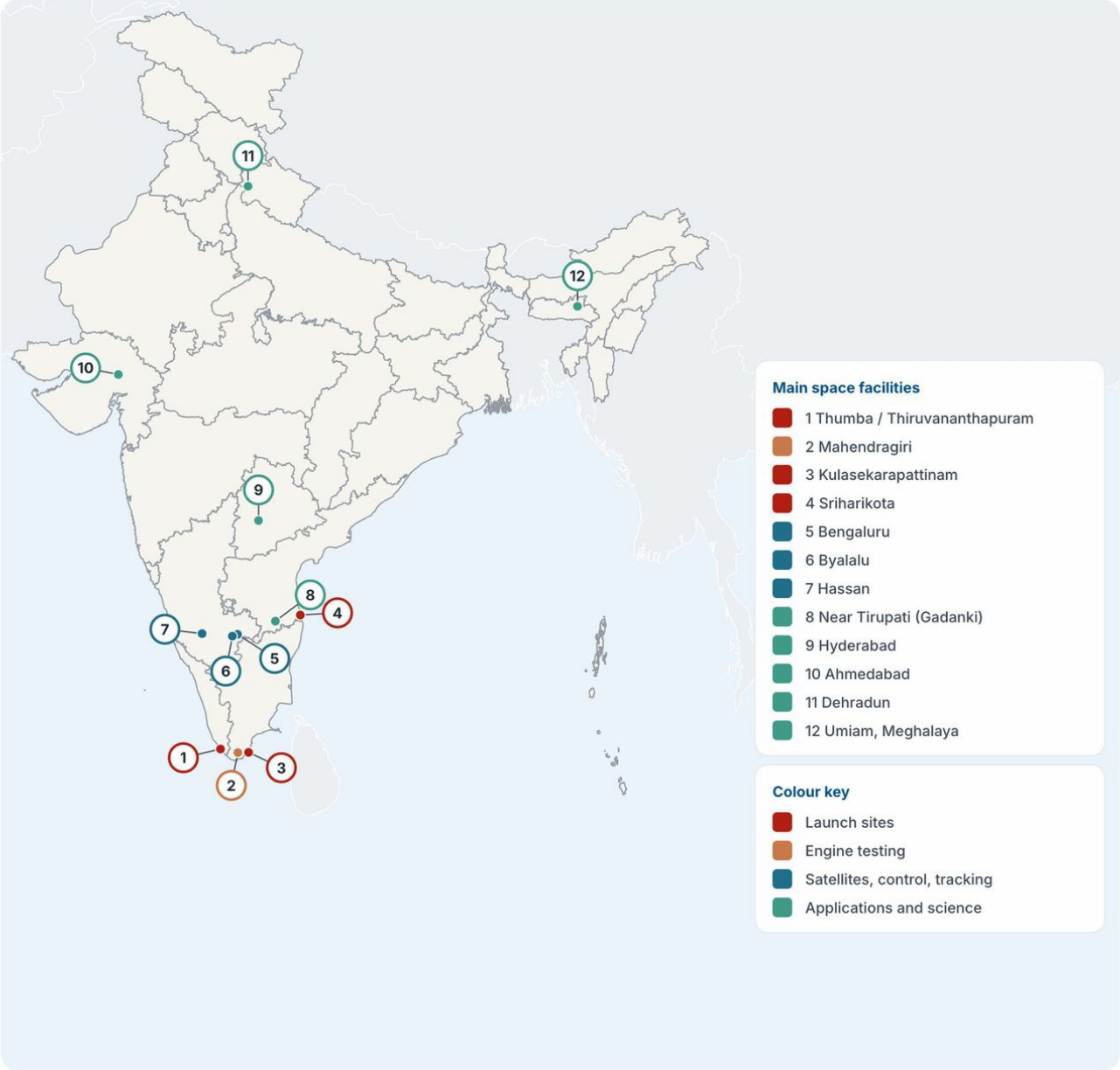
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Geography of the Space Establishment

TRANSPORT, COMMUNICATION AND TRADE · SPACE

Main Space Facilities of India

Launch sites keep to the south-eastern and southern coast, while research and control cluster in Bengaluru, Ahmedabad and Thiruvananthapuram.



Positions are approximate, and offset markers are joined to their locations by leader lines. Kulasekarapattinam is under construction. Boundaries: Survey of India outline (datameet).

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PLACE	FACILITY	ROLE
Thumba, Thiruvananthapuram	Vikram Sarabhai Space Centre, Thumba Equatorial Rocket Launching Station	Launch vehicle design, sounding rockets

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PLACE	FACILITY	ROLE
Valiamala	Liquid Propulsion Systems Centre	Liquid and cryogenic stages
Mahendragiri	ISRO Propulsion Complex	Engine and stage testing
Sriharikota	Satish Dhawan Space Centre	India’s spaceport
Kulasekarapattinam	SSLV Launch Complex	Polar launches, under construction
Bengaluru	ISRO Headquarters, U R Rao Satellite Centre, ISTRAC, Human Space Flight Centre	Satellites, tracking, crewed flight
Byalalu	Indian Deep Space Network	Deep-space tracking
Hassan	Master Control Facility	Control of geostationary satellites
Ahmedabad	Space Applications Centre, Physical Research Laboratory, IN-SPACe	Payloads, research, private-sector regulation
Hyderabad	National Remote Sensing Centre	Satellite data and mapping
Dehradun	Indian Institute of Remote Sensing	Training in remote sensing
Near Tirupati	National Atmospheric Research Laboratory	Atmospheric research
Umiam, Meghalaya	North Eastern Space Applications Centre	Development support to the North-East

- Why Thumba: it lies **close to the magnetic equator**, which suits the study of the upper atmosphere. It was chosen as an international sounding-rocket site.
- Why Sriharikota: this island on the east coast, about 80 km north of Chennai, allows **eastward launches over the sea**, helped by the Earth’s rotation at a low latitude.
  - It began operating in **1971** with a **Rohini-125** sounding rocket. It was renamed after **Prof. Satish Dhawan**, who carried forward the work of Vikram Sarabhai.
- Why Kulasekarapattinam: this site in Thoothukudi district, Tamil Nadu, is meant for **polar launches of the SSLV** and for private rockets.
- **Ground stations** of ISTRAC include Lucknow, Port Blair and Thiruvananthapuram, with others in Mauritius, Brunei and Biak (Indonesia).

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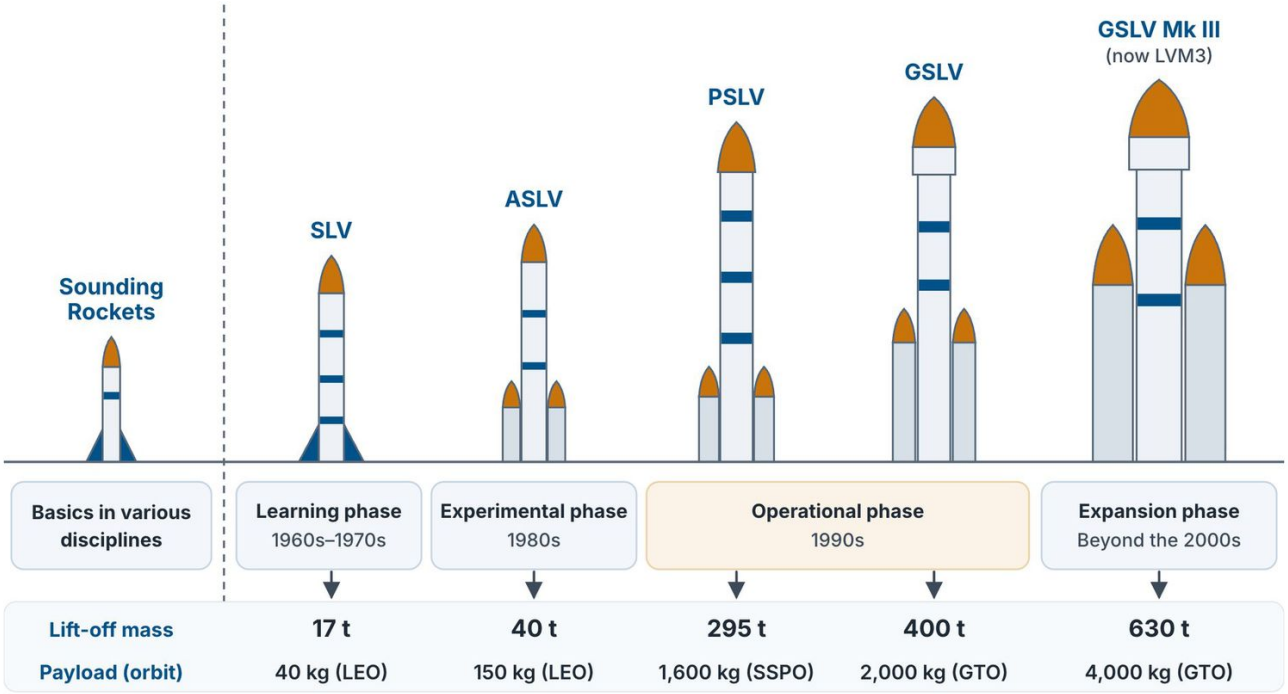
02 Launch Vehicles

- The **launch vehicle programme** grew through sounding rockets, SLV, ASLV, PSLV, GSLV and LVM3, each of these **satellite launch vehicles** building on the last.

SPACE · LAUNCH VEHICLES

Growth of India's Launch Vehicles

From sounding rockets to GSLV Mk III, with lift-off mass and payload as early design values.



LEO: low earth orbit **SSPO:** sun-synchronous polar orbit **GTO:** geosynchronous transfer orbit

Not to scale. lotusarise.com

- The figure gives early design values. **Current lift-off masses** are about 320 t (PSLV-XL), 420 t (GSLV) and 640 t (LVM3), as the table shows.

VEHICLE	STAGES	LIFT-OFF MASS	PAYLOAD	KEY DATES	STATUS, OCTOBER 2026
SLV-3	4, all solid	17 t	40 kg to low earth orbit (LEO)	Failed 10 Aug 1979; success 18 Jul 1980	Retired
ASLV	5, all solid	40 t	150 kg to 400 km	Failed 1987, 1988; success 20 May 1992	Retired

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VEHICLE	STAGES	LIFT-OFF MASS	PAYLOAD	KEY DATES	STATUS, OCTOBER 2026
PSLV	4, solid and liquid	320 t (XL)	1,750 kg to sun-synchronous polar orbit	Failed 20 Sep 1993; success 15 Oct 1994	Grounded since Jan 2026
GSLV	3, with cryogenic stage	420 t	2,250 kg to geosynchronous transfer orbit (GTO)	First flight 18 Apr 2001; indigenous cryogenic stage 5 Jan 2014	Active
LVM3 (GSLV Mk III)	3	640 t	4,200 kg to GTO; 8,000 kg to LEO	Suborbital 18 Dec 2014; orbital 5 Jun 2017	Active
SSLV	3 solid, plus trim module	about 120 t	500 kg to LEO	Failed 7 Aug 2022; success 10 Feb 2023	Passing to industry

- **Sounding rockets** are **one- or two-stage solid rockets** that probe the upper atmosphere and test parts for bigger vehicles.
  - The **first came from abroad**. **RH-75**, of 75 mm diameter, was the first truly Indian one, flown from Thumba in **1967**.
  - RH-100, 125, 200, 300 and 560 followed, and over 1,000 have flown. ISRO flew 12 Rohini flights in 2025.
- **PSLV** became the **workhorse**, carrying remote-sensing, navigation and small foreign satellites. It lifted **104 satellites on 15 February 2017**.
  - **Two straight failures** followed, both in the **third stage: PSLV-C61 (18 May 2025) and PSLV-C62 (12 January 2026)**.
  - A **National Level Expert Committee** is reviewing them, and no PSLV had flown again by 30 October 2026.
- **GSLV** made India self-reliant in launching **communication and navigation satellites.** Its **cryogenic upper stage** was the hard step.
- **LVM3** carried **Chandrayaan-2 and Chandrayaan-3**, and two OneWeb missions of 72 satellites.
  - **CMS-03**, about **4,400 kg**, was the **heaviest satellite sent to GTO from Indian soil** (2 November 2025).
  - **BlueBird Block-2**, a satellite of about 6 tonnes for the American firm AST SpaceMobile, became the **heaviest launched from India** (24 December 2025).
- Launch pads at Sriharikota:
  - First Launch Pad: PSLV and SSLV, and Vikram-1 in 2026.
  - Second Launch Pad: GSLV and LVM3, including the human-rated LVM3.
  - Third Launch Pad: approved on 16 January 2025 at **₹3,984.86 crore**, to be ready within four years, for next-generation vehicles.

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- New launch site: the foundation stone at **Kulasekarapattinam** was laid on 28 February 2024, and that of its launch pad on 27 August 2025. Completion is targeted for the end of 2026.
- Next-generation technology:
  - Next Generation Launch Vehicle (NGLV): approved in September 2024 at about ₹8,240 crore, to lift up to **30 tonnes to LEO**.
  - Semi-cryogenic and LOX-methane engines: the first ignition of a full-scale gas generator for the 1,100 kN LOX-methane engine came on **9 October 2026**.
  - **Reusable Launch Vehicle Technology Demonstrator:** flown on 23 May 2016. **Scramjet Engine Technology Demonstrator:** flown on 28 August 2016.

03 Satellites and Their Applications

PYQ 2023 · 2022 · 2017

Communication Satellites: INSAT and GSAT

- The **Indian National Satellite (INSAT) system** is one of the **largest domestic communication satellite systems in the Asia-Pacific region**, placed in **geostationary orbit**. It serves telecommunications, television and meteorology together.
- A **transponder** receives radio signals from the ground and retransmits them. **INSAT-1** offered 12 transponders and about 4,300 two-way telephone circuits for national coverage.

GENERATION	SATELLITES AND LAUNCH DATES	REMARKS
APPLE	19 Jun 1981	Ariane Passenger Payload Experiment, an experimental geostationary satellite, from Kourou; lasted 27 months against a design life of two years
INSAT-1, procured abroad	1A: 10 Apr 1982; 1B: 30 Aug 1983; 1C: 22 Jul 1988; 1D: 12 Jun 1990	1A deactivated 6 Sep 1982. 1B outlived its design life. 1C worked at half capacity for communication and was abandoned in Nov 1989
INSAT-2, indigenous	2A: 10 Jul 1992; 2B: 23 Jul 1993; 2C: 7 Dec 1995; 2D: 4 Jun 1997; 2E: 3 Apr 1999	More capacity, better weather imaging. 2D failed in orbit
INSAT-3	3B: 22 Mar 2000; 3C: 24 Jan 2002; 3A: 10 Apr 2003; 3E: 28 Sep 2003	3B opened the third generation, by Ariane from Kourou
INSAT-4	4A: 22 Dec 2005; 4B: 12 Mar 2007; 4CR: 2 Sep 2007	Direct-to-home television

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GENERATION	SATELLITES AND LAUNCH DATES	REMARKS
GSAT and CMS	EDUSAT (GSAT-3): 20 Sep 2004; GSAT-29: 14 Nov 2018; GSAT-N2: 19 Nov 2024; CMS-03: 2 Nov 2025	EDUSAT for education; GSAT-N2 launched by Falcon-9

- Operational roster: an older count listed 14 satellites: INSAT-3A, 3C, 4A, 4B, 4CR and 3DR, and GSAT-6, 7, 8, 10, 12, 14, 15 and 16, of which nine were then described as operational in geostationary orbit.
  - ISRO's October 2026 list marks **19 communication satellites as operational**, from GSAT-10 to CMS-03. INSAT-3A, 3C, 4A, 4B, 4CR, GSAT-8 and GSAT-12 have left service.
- Applications of INSAT:
  - Educational television services, as with EDUSAT (2004), meant to offset the shortage of qualified teachers.
  - Telemedicine.
  - Television.
  - Satellite-aided search and rescue.
  - Disaster management.
  - **Geopolitics**, as with the South Asia Satellite (GSAT-9, 5 May 2017), first planned as a SAARC satellite.
  - **Commercialisation**, as with launches of communication satellites for foreign customers, including American firms.
- Roots in development: Sarabhai took part in an early study with NASA on using satellites for direct television broadcasting. This led to the **Satellite Instructional Television Experiment (SITE, 1975–76)**.

Remote Sensing Satellites: IRS

- Early experiments: Bhaskara-I (7 June 1979) and Bhaskara-II (20 November 1981) studied land use, forests, Himalayan snow cover, drought-prone areas and geological structure.
- Starting with **IRS-1A on 17 March 1988**, which carried Linear Imaging Self-Scanning Sensors, ISRO has built **one of the largest remote-sensing constellations** in operation.
- **Families of satellites**: the Cartosat, Oceansat, Resourcesat and Radar Imaging Satellite (RISAT) series. **RISAT** carries radar that sees through cloud, while **Resourcesat** is an optical series for natural resources.

SATELLITE	LAUNCH	MAIN USE
IRS-1C	28 Dec 1995	Second generation; served about ten years
IRS-P3	21 Mar 1996	Experimental sensors over land and sea
IRS-1D	29 Sep 1997	Land imaging, first on an operational PSLV
Oceansat-1	26 May 1999	Fish resources, sea level, sediment, pollution, sea temperature

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SATELLITE	LAUNCH	MAIN USE
Technology Experiment Satellite	22 Oct 2001	New imaging technology for cartography
Resourcesat-1	17 Oct 2003	Natural resource estimates
Cartosat-1 and 2	5 May 2005; 10 Jan 2007	Topographical maps
RISAT-1	26 Apr 2012	Radar imaging
INSAT-3DR and 3DS	8 Sep 2016; 17 Feb 2024	Weather
Oceansat-3 (EOS-06)	26 Nov 2022	Ocean observation
NISAR	30 Jul 2025	First joint ISRO–NASA mission; first dual-frequency radar satellite
EOS-05 (GISAT-1A)	4 Sep 2026	India's first imaging satellite from geosynchronous orbit

- **EOS-05** replaced the lost EOS-03 of 12 August 2021, and reached a near-geostationary orbit of 34,903 km by 35,884 km by 7 September 2026.
- Losses: RISAT-1B (EOS-09) was lost on PSLV-C61, and **Anvesha (EOS-N1)** on PSLV-C62.
- Applications of IRS:
  - Disaster management support: after the **Dharali flash flood** in Uttarkashi on 5 August 2025, Cartosat images gave a damage assessment within two days.
    - ISRO also took the lead of the **International Charter on Space and Major Disasters** for six months from April 2025.
  - Weather: INSAT-3D outgoing longwave data can flag **lightning about 2.5 hours ahead**.
  - Bio-resources and environmental survey and mapping, for example Resourcesat.
  - **Cartography**, for example Cartosat.
  - Agriculture and soil: the **CROP framework** tracked wheat sowing in major growing States in the rabi season of 2024–25, using EOS-04, EOS-06 and Resourcesat-2A.
  - Rural and urban development, for example the National Drinking Water Mission.

Satellite Navigation: IRNSS and NavIC PYQ 2022 · 2017

- The **Indian Regional Navigation Satellite System (IRNSS)**, now **Navigation with Indian Constellation (NavIC)**, gives **position, navigation and timing** over India and about **1,500 km beyond**.
  - It was planned as a constellation of **seven satellites** with a ground segment. The need for an independent system was felt during the **Kargil conflict of 1999**.

- First generation: IRNSS-1A (1 July 2013) to IRNSS-1G (28 April 2016). **IRNSS-1H** failed on 31 August 2017 and **IRNSS-1I** replaced it on 12 April 2018.
- **Second generation, the NVS series,** adds the civil **L1 signal** to L5 and S.
  - NVS-01: 29 May 2023.
  - NVS-02: 29 January 2025, on the **100th launch from Sriharikota**. It reached transfer orbit but could not raise its orbit, because the drive signal failed to reach a pyro valve.
  - NVS-03: **30 October 2026** on GSLV-F18, the **20th GSLV flight**. It weighs about 2,250 kg and carries an **indigenous atomic clock**, and it still has to raise its orbit and enter service.
  - **NVS-04 and NVS-05** are in advanced stages of realisation.
- Status: a Lok Sabha reply of **July 2026** said only **three satellites (IRNSS-1B, IRNSS-1I and NVS-01)** gave navigation service, while **at least four** are needed for positioning.
  - The onboard clock of **IRNSS-1F stopped on 13 March 2026**. Older satellites carry on with messaging and disaster alerts, and the timing service continues.
  - **Atomic clock failures** and launch losses caused this gap, so NavIC remains **strategically valuable but operationally incomplete**.

04 Important Milestones

Early Rocketry and Phase I: 1960–70 (Incipient Stage)

- Rockets used by the **Mysore armies** against the British inspired **William Congreve's rocket of 1804**.
- **Vikram Ambalal Sarabhai (1919–1971)** was the **founding father** of the programme and a scientific visionary. He founded a cosmic-ray laboratory, and **Homi Jehangir Bhabha (1909–1966)** also worked on cosmic rays in the 1940s.
- After Sputnik in 1957, Sarabhai saw the potential of satellites. India's first Prime Minister, **Jawaharlal Nehru**, who saw science as essential to the country's future, placed space research under the **Department of Atomic Energy** in **1961**.
- **Bhabha**, who headed the Department of Atomic Energy (DAE) and is regarded as the father of India's atomic programme, set up **INCOSPAR**, the **Indian National Committee for Space Research**, in **1962**, with Sarabhai as its Chairman.
- The programme began with **sounding rockets** from the **Thumba Equatorial Rocket Launching Station (TERLS)** near Thiruvananthapuram in south Keralam (Kerala).
- India developed its own **Rohini family** of sounding rockets, and the Thumba complex became the **Vikram Sarabhai Space Centre**.
- **ISRO was created in 1969**, and the **Department of Space in 1972**.

Phase II: 1970–80

- India began building **satellite technology**, anticipating its future needs in remote sensing and communication.
- **Aryabhata**, its first satellite, went up on a **Soviet booster in 1975**.

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- By 1979 the **SLV** was ready at the new **Sriharikota Rocket Launching Station (SRLS)**. The first launch that year failed, through a control failure in the second stage.
- By 1980 the fault was cured, and **Rohini** became the first satellite that India put into orbit with its own launcher. **SLV-3** made India the **sixth space-faring nation**.

Phase III: 1980–90

- ISRO then wanted a launch vehicle that could put a **truly useful satellite into polar orbit**.
- The **Augmented Satellite Launch Vehicle (ASLV)** was tested in **1987**, and the launch failed. Another attempt in 1988, after minor corrections, also failed.

Phase IV: 1990–2000

- The first successful **ASLV** launch came in **1992**.
- The **PSLV** first succeeded in **1994**. It went on to place remote-sensing and communication satellites into orbit, building a large cluster and supplying data for Indian industry and agriculture.
- In **1999** PSLV carried foreign satellites from Germany and Korea for the first time, as co-passengers.

Developments after 2000

- The **first development flight of the GSLV** came in **2001**.
- **Chandrayaan-1**, an uncrewed probe to the Moon, flew in **2008** as the first step in exploring the solar system.
- ISRO entered the **lucrative market of launching foreign payloads** from Indian soil. **434 foreign satellites** had been launched by January 2026, 399 of them after 2014.
- **After 2010** the work ran along three lines:
  - Launch vehicles: PSLV, GSLV and the next-generation GSLV Mark III.
  - Earth observation: Resourcesat, Cartosat, Oceansat, Radar Imaging Satellite and Geo-Imaging Satellite, and weather and climate satellites such as INSAT-3DR.
  - Satellite navigation: the seven-satellite IRNSS with its ground segment.

Dateline of the Indian Space Programme PYQ 2019

YEAR	EVENT
1962	INCOSPAR formed by the Department of Atomic Energy; work starts on TERLS
1963	First sounding rocket from TERLS (21 November)
1965	Space Science and Technology Centre (SSTC) set up at Thumba
1967	Ahmedabad gets the Satellite Telecommunication Earth Station

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YEAR	EVENT
1968	TERLS dedicated to the United Nations (2 February)
1969	ISRO formed under the Department of Atomic Energy (15 August)
1972	Department of Space and Space Commission created (1 June); ISRO placed under the Department
1975	ISRO becomes a Government organisation (1 April); Aryabhata launched (19 April)
1979	Bhaskara-I, an experimental earth-observation satellite (7 June); first experimental SLV-3 launch with Rohini Technology Payload fails to reach orbit (10 August)
1980	Second SLV-3, Rohini placed in orbit (18 July)
1982	INSAT-1A launched (10 April), deactivated (6 September)
1984	Indo-Soviet crewed mission
1988	IRS-1A (17 March); ASLV with SROSS-2 fails to reach orbit (13 July); INSAT-1C (22 July), abandoned November 1989
2000	INSAT-3B, first of the third generation, launched by Ariane from Kourou, French Guiana (22 March)
2004	First operational GSLV flight (GSLV-F01) launches EDUSAT from the Satish Dhawan Space Centre (SDSC), Sriharikota (20 September)
2007	SRE-1 re-enters and is recovered from the Bay of Bengal, about 140 km east of Sriharikota
2008	PSLV-C11 launches Chandrayaan-1 (22 October)
2012	PSLV-C21, the 100th ISRO mission (9 September)
2013	PSLV-C25 launches the Mars Orbiter Mission (5 November)
2015	PSLV-C30 launches ASTROSAT of 1,513 kg, with six foreign satellites (28 September)
2016	Reusable Launch Vehicle Technology Demonstrator (RLV-TD) (23 May); Scramjet Engine Technology Demonstrator (28 August)
2017	PSLV-C37 launches a Cartosat-2 series satellite and 103 others, 104 in one go (15 February)
2019	Chandrayaan-2 launched (22 July); its orbiter is still in service
2023	Chandrayaan-3 lands near the lunar south pole (23 August); Aditya-L1 launched (2 September)

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YEAR	EVENT
2024	XPoSat (1 January); Aditya-L1 enters its halo orbit (6 January); INSAT-3DS (17 February); SpaDeX (30 December)
2025	NVS-02, the 100th Sriharikota launch (29 January); Shubhanshu Shukla reaches the ISS (June); NISAR (30 July); CMS-03 (2 November); BlueBird Block-2 (24 December)
2026	PSLV-C62 fails (12 January); Vikram-1, first private orbital launch (18 July); EOS-05 (4 September); NVS-03 (30 October)

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SPACE · DATELINE

ISRO's Key Milestones, 1975 to 2019

Key launches and missions up to September 2019.



- The chart stops at 2019. **INSAT-1A (1982)** opened the INSAT series, while INSAT-2A was the first of the indigenous second generation. GSAT-29 has since been overtaken as the heaviest satellite from India, by CMS-03 and BlueBird Block-2, and the 104-satellite record has been passed abroad.

05 Science, Exploration and Crewed Flight

- Since 2008 the **important missions of ISRO** and its **major milestones** have reached the Moon, Mars and the Sun, using the orbits and satellite types of **space technology**.

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Moon, Mars and Sun

MISSION	LAUNCH	VEHICLE	ACHIEVEMENT
Chandrayaan-1	22 Oct 2008	PSLV-C11	Reached a 100 km lunar orbit; Moon Impact Probe struck near Shackleton crater on 14 Nov 2008; helped detect water molecules
Mars Orbiter Mission	5 Nov 2013	PSLV-C25	Entered Mars orbit on 24 Sep 2014, India's first interplanetary mission
AstroSat	28 Sep 2015	PSLV-C30	India's first dedicated astronomy mission; still in service
Chandrayaan-2	22 Jul 2019	GSLV Mk III	Lander lost on 7 Sep 2019; orbiter still working
Chandrayaan-3	14 Jul 2023	LVM3-M4	**First soft landing near the lunar south pole**, 23 Aug 2023, now National Space Day
Aditya-L1	2 Sep 2023	PSLV-C57	Solar observatory in a halo orbit around the L1 point, about 1.5 million km from Earth
XPoSat	1 Jan 2024	PSLV-C58	X-ray polarimetry
SpaDeX	30 Dec 2024	PSLV-C60	**India the fourth nation to dock in space**; both craft re-entered on 12 Oct 2026

- **Chandrayaan-1** cost only **₹386 crore**. Contact was lost in late August 2009, after it had met most of its goals in place of a planned two-year life.
- **Mars Orbiter Mission** weighed 1,337 kg at lift-off. It spent about a month in Earth orbit, raising its orbit in steps, before leaving for Mars. It was tracked from ISTRAC with the Indian Deep Space Network.
- **Chandrayaan-2** was launched by GSLV with an orbiter, a lander and a rover.

Human Spaceflight

- Gaganyaan: in September 2024 the Cabinet allotted **₹20,193 crore for eight missions** under the human spaceflight programme.
  - **G1**, the **first uncrewed flight carrying the half-humanoid Vyommitra**, was targeted for the **fourth quarter of 2026** in a Rajya Sabha reply of 6 August 2026.
  - Two more uncrewed flights are targeted by 2027, before the first crewed orbital mission.
- Vehicle: the human-rated LVM3 (HLVM3) stands 53 m tall, weighs 640 tonnes and can lift about 10 tonnes to LEO.
- Tests so far: the TV-D1 crew escape test, integrated air drop tests on 24 August 2025 and in April 2026, and crew module separation tests reported in **October 2026**. Ground tests had passed **8,000**.

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- Crew: Prasanth Balakrishnan Nair, Angad Pratap, Ajit Krishnan and Shubhanshu Shukla were named on 27 February 2024.
  - **Shukla** became the **first Indian aboard the International Space Station** on **Axiom-4** (25 June to 15 July 2025), and the second Indian in space after **Rakesh Sharma**, who flew on the 1984 Indo-Soviet mission.

Roadmap

TARGET	MISSION	PURPOSE
Approved September 2024	**Chandrayaan-4**	India's first lunar sample return; about ₹2,104 crore
March 2028	**Venus Orbiter Mission**	Venus surface and atmosphere; about ₹1,236 crore
By 2028	**BAS-01**	First module of the **Bharatiya Antariksh Station**
Under development with Japan	**Chandrayaan-5 / LUPEX**	Lunar volatiles near the south pole; ISRO lander on Japan's H3 rocket, Japanese rover
2035	**Bharatiya Antariksh Station**	Five-module Indian space station
2040	**Crewed lunar landing**	An Indian on the Moon

06 Policy and the Private Sector PYQ 2020

- **Space sector reforms of 2020** ended the near-monopoly of government, and ISRO now reports more than **440 space start-ups** (August 2026), from single digits before.
- Institutions:
  - **NewSpace India Limited (NSIL)**, incorporated on **6 March 2019**, is ISRO's commercial arm. **Antrix Corporation** also sits under the Department.
  - **IN-SPACe**, the **Indian National Space Promotion and Authorisation Centre** at Ahmedabad, is the **single-window autonomous agency** that promotes, authorises and supervises private activity and shares ISRO facilities.
- **Indian Space Policy, 2023** allows private entities to carry out **end-to-end activities**.
  - **ISRO** shifts its focus to **research and development** of advanced technology and new systems.
  - **IN-SPACe** authorises, **NSIL** commercialises, and the **Department of Space** provides overall direction.
- Foreign investment (21 February 2024): automatic route up to **74%** for satellite manufacture and operation and data products, **49%** for launch vehicles and spaceports, and **100%** for components and systems.

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- Funding: a **₹1,000 crore venture capital fund** (approved 24 October 2024) and a ₹500 crore Technology Adoption Fund. Private investment rose from US$ 100.5 million in 2021–22 to US$ 618.5 million by March 2026.
- Private launches:
  - **Skyroot's Vikram-S**, a suborbital test (18 November 2022).
  - **Agnikul's Agnibaan SOrTeD** from its own pad at Sriharikota (30 May 2024).
  - **Skyroot's Vikram-1** on **18 July 2026**, the **first orbital launch from Indian soil by a private company**, on its first attempt from the First Launch Pad.
- Handover to industry:
  - PSLV: a contract with the HAL and L&T consortium for five PSLV-XL vehicles. Stacking of the first, **PSLV-N1**, had begun by March 2026.
  - SSLV: full technology transfer to **Hindustan Aeronautics Limited**, signed on 10 September 2025.
  - Earth observation: a **Pixxel-led consortium** will invest over ₹1,200 crore in **12 satellites** under public-private partnership.
- Space economy: about **US$ 8.4 billion** on the January 2026 government estimate and about US$ 9 billion on that of August 2026, with **US$ 40–45 billion** expected within a decade.
- Regional effect: clusters are forming around Bengaluru, Ahmedabad and Thiruvananthapuram, and Gujarat has a **Space Park** on offer.

Space and National Security

PYQ 2024 · 2020 · 2019

- Gains:
  - **Independent navigation** through NavIC.
  - **Secure communication and maritime reach**, as with CMS-03 (GSAT-7R), which serves a wide oceanic region.
  - **Surveillance** through radar and optical satellites.
  - An **anti-satellite capability**, shown against **Microsat-R** in March 2019.
- Concerns with private entry:
  - Control of **dual-use technology** and high-resolution imagery.
  - **Foreign ownership** and data security, which explains the sector-wise FDI caps.
  - **Absence of a space activities law**, so that IN-SPACe rests on policy and not on statute.
  - **Space debris** and crowded orbits.
- Vulnerabilities shown recently: the two PSLV failures and the NavIC shortfall show how much depends on **launch reliability and timely replacement**.

Indian Space Policy, 2023

PYQ 2024

- **Roles:** the policy of 2023 makes **IN-SPACe** the authorising body, **NewSpace India Limited** the commercial arm, and leaves **ISRO** to focus on research and advanced missions.
- **Private presence:** firms may build satellites, launch vehicles and ground stations and sell data. Skyroot flew Vikram-S in 2022, and foreign investment was liberalised in 2024.

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- **Benefits:**
  - **Socio-economic:** satellite services for farming, fishing, weather, disaster warning, education and telemedicine, plus skilled jobs.
  - **Security:** more satellites for surveillance and communication, and faster launch capacity.
- **Concerns:** private firms need finance, clear liability rules and a space law.

Previous Year Questions

2025	Map item: Byalalu
2024	The Indian Space Policy, 2023 supports commercial presence in space. In what ways will it benefit the socio-economic development and security of India?
2023	Examine the role of Indian Earth observation satellite technology in enhancing weather forecasting and disaster management.
2022	Critically examine the role of the IRNSS-NavIC programme in the satellite navigation system of India.
2020	India has opened up its space to private sectors for satellite-based activities. Critically examine its implications, indicating the major security concerns.
2019	Examine ongoing space programmes of India and their implications for national security in future.
2017	Bring out the significance of the Indian Regional Navigation Satellite System (IRNSS).
2017	Map item: Thumba
2024	The Indian Space Policy, 2023 supports the commercial presence in space. In what ways will it benefit the socio-economic development and security of India?
2022	Critically examine the role of IRNSS-NavIC programme on the satellite navigation system of India.
2017	Bring out the significance of Indian Regional Navigation Satellite System (IRNSS).

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