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INDIAN SPACE PROGRAM

- The Indian Space Programme began in 1962.
- In 1969 the Indian Space Research Organization (ISRO) was set up with headquarters in Bangalore for the purpose of rapid development in space technology and its application.
- In 1972, Space Commission was established.
- In 1975, India launched its first satellite, Aryabhata, and thus entered the space age.
- Over the last two and half decades, the Indian Space Programme has made impressive progress through a well integrated, self-reliant programme. Its main objectives are –
  (i) Mass Communication and education via Satellite;
  (ii) Survey and management of natural resources through remote sensing technology, environmental monitoring and meteorological forecasting and
  (iii) Development of indigenous satellites and satellite launch vehicles.
- The Space Programme of the country can be divided broadly into three phases:
  (i) Experimental phase,
  (ii) Operational phase, and
  (iii) Space Research

Indian Space Research Organisation (ISRO)

- The **Indian Space Research Organisation** (**ISRO)** is the primary space agency of the Indian government.
- ISRO is amongst the six largest government space agencies in the world.
- Its primary objective is to advance space technology and use its applications for national benefit.
- ISRO is under the administrative control of the Department of Space, Government of India.
- India's first satellite, Aryabhata, was built by ISRO and launched by the Soviet Union in 1975.
- Rohini, the first satellite to be placed in orbit by an Indian-made launch vehicle, SLV-3, was launched in 1980.
- In 2008, ISRO successfully launched its first lunar probe, Chandrayaan-1.
- The objective of ISRO (Indian Space Research Organization) is to develop space technology and its application to various tasks of national and international interest. Accordingly, it has successfully put into operation two major satellite systems, namely the Indian National satellites (INSAT) for communication services and the Indian Remote Sensing (IRS) satellites for management of natural resources. It has also developed various launch vehicles, like the Polar Satellite Launch Vehicle (PSLV), the Geosynchronous Satellite Launch Vehicle (GSLV), etc. for launching satellites.

Satellite Launch Vehicle (SLV)

Version	Date of Launch	Launch Location	Payload
3 D1	10 August 1979	SDHC, Sriharikota	Rohini-1A Experimental Technology mission, 30 kg
3 D2	18 July 1980	SDHC, Sriharikota	Rohini-1B RS-1 Experimental Technology mission, 35 kg
3 D3	31 May 1981	SDHC, Sriharikota	Rohini D-1 RS-1 Experimental Technology mission, 38 kg
3 D4	17 April 1983	SDHC, Sriharikota	Rohini D-2 RS-1 Experimental Technology mission, 41.5 kg

Augmented Satellite Launch Vehicle (ASLV)

S/N	**Launch date**	**Payload**	**Outcome**	**Remarks**
D1	24 March 1987	SROSS A, 150 kg	Failure	First stage did not ignite after strap-on burnout.
D2	13 July 1988	SROSS-B, 150 kg	Failure	Insufficient control gain
D3	20 May 1992	SROSS-C, 106 kg	Partial failure	Lower than expected orbit and incorrect spin-stabilisation, payload decayed quickly.
D4	4 May 1994	SROSS-C2, 113 kg	Success	

Polar Satellite Launch Vehicle (PSLV)

PSLV has 3 variants

1) PSLV (Using 6 strap on boosters)
2) PSLV-CA (Using only the core vehicle without using any strap on boosters)
3) PSLV – XL (Using stretched strap on boosters)

Flight	**Variant**	**Launch date/time (UTC)**
D1	PSLV	20 September 1993
D2	PSLV	15 October 1994

D3	PSLV	21 March 1996
C1	PSLV	29 September 1997
C2	PSLV	26 May 1999
C3	PSLV	22 October 2001
C4	PSLV	12 September 2002
C5	PSLV	17 October 2003
C6	PSLV	5 May 2005
C7	PSLV	10 January 2007
C8	PSLV-CA	23 April 2007
C10	PSLV-CA	21 January 2008
C9	PSLV-CA	28 April 2008
C11	PSLV-XL	22 October 2008
C12	PSLV-CA	20 April 2009
C14	PSLV-CA	23 September 2009
C15	PSLV-CA	12 July 2010
C16	PSLV	20 April 2011
C17	PSLV-XL	15 July 2011
C18	PSLV-CA	12 October 2011
C19	PSLV-XL	26 April 2012
C21	PSLV-CA	9 September 2012
C20	PSLV-CA	25 February 2013
C22	PSLV-HP	June 2013
C25	PSLV-XL	25 October 2013

Geosynchronous Satellite Launch Vehicle (GSLV) Variants

GSLV Mk I (a): This variant had a 125 t (S-125) first stage and was capable of launching 1500 kg into geostationary transfer orbit. This is now retired.

GSLV Mk I (b): This variant had 139 t (S-139) first stage and improved fuel in the strap-on boosters & second stage. This variant can launch 1900 kg into geostationary transfer orbit.

GSLV Mk I (c): This variant has a 15 tonne third stage. GSLV-F06 (flight 6) is the only attempted launch of the Mark I(c) version to date.

GSLV Mk II: This variant uses an Indian cryogenic engine and is capable of launching 2500 kg into geostationary transfer orbit. Previous GSLV vehicles (GSLV Mk I) have used Russian cryogenic engines.

GSLV Mk III: This rocket is the technological successor to the GSLV, however is not derived from its predecessor.

Launch history: All GSLV launches have been conducted from the Satish Dhawan Space Centre in Sriharikota.

Flight	Launch date	Variant	Payload
D1	18 April 2001	Mk I(a)	GSAT-1
D2	8 May 2003	Mk I(a)	GSAT-2
F01	20 September 2004	Mk I(b)	EDUSAT
F02	10 July 2006	Mk I(b)	INSAT-4C
F04	2 September 2007	Mk I(b)	INSAT-4CR
D3	15 April 2010	Mk II	GSAT-4
D4	25 December 2010	Mk I(c)	GSAT-5P
D5	May 2013	Mk II	GSAT-14

Geosynchronous Satellite Launch Vehicle Mark-III (GSLV III)

- The Geosynchronous Satellite Launch Vehicle Mark-III is a launch vehicle currently under development by the Indian Space Research Organisation.

1. It is intended to launch heavy satellites into geostationary orbit, and will allow India to become less dependent on foreign rockets for heavy lifting. The rocket, though the technological successor to the GSLV, however is not derived from its predecessor. The first experimental Mission of GSLV-Mark III is scheduled for August 2014 launch.

The INSAT series of satellites:

KALPANA-1

KALPANA-1 is an exclusive meteorological satellite launched by PSLV in September 2002. It carries Very High Resolution Radiometer and DRT payloads to provide meteorological services. It is located at 74 degree East longitude.

Edusat

Configured for audio-visual medium employing digital interactive classroom lessons and multimedia content, EDUSAT was launched by GSLV in September 2004. Its transponders and their ground coverage are specially configured to cater to the educational requirements. The satellite carries a K_u band transponder covering the Indian mainland region with 50 dBW EIRP, five K_u band spot beam transponders for South, West, Central, North and North East regional coverage with 55 dBW EIRP and six Extended C-band transponders with India coverage with 37 dBW EIRP. EDUSAT is positioned at 74 degree East longitude and is collocated with KALPANA-1 and INSAT-3

IRS launch log

The initial versions are composed of the 1 (A, B, C, D). The later versions are named based on their area of application including OceanSat, CartoSat, ResourceSat. Some of the satellites have alternate designations based on the launch number and vehicle (P series for PSLV).

Satellite	Date of Launch	Launch Vehicle	Status
IRS 1A	17 March 1988	Vostok, USSR	Mission Completed
IRS 1B	29 August 1991	Vostok, USSR	Mission Completed
IRS P1 (also IE)	20 September 1993	PSLV-D1	Failure of PSLV
IRS-P2	15 October 1994	PSLV-D2	MissionCompleted
IRS-1C	28 December 1995	Molniya, Russia	MissionCompleted
IRS-P3	21 March 1996	PSLV-D3	MissionCompleted
IRS 1D	29 September 1997	PSLV-C1	MissionCompleted
IRS-P4 (Oceansat-1)	27 May 1999	PSLV-C2	MissionCompleted
Technology Experiment Satellite (TES)	22 October 2001	PSLV-C3	MissionCompleted

IRS P6 (Resourcesat-1)	17 October 2003	PSLV-C5	In Service
IRS P5 (Cartosat 1)	5 May 2005	PSLV-C6	In Service
Cartosat 2 (IRS P7)	10 January 2007	PSLV-C7	In Service
Cartosat 2A	28 April 2008	PSLV-C9	In Service
IMS 1	28 April 2008	PSLV-C9	In Service
Oceansat-2	23 September 2009	PSLV-C14	In Service
Cartosat-2B	12 July 2010	PSLV-C15	In Service
Resourcesat-2	20 April 2011	PSLV-C16	In Service
Megha-Tropiques	12 October 2011	PSLV-C18	In Service
RISAT-1	26 April 2012	PSLV-C19	In Service
SARAL	25 Feb 2013	PSLV-C20	In Service

Resourcesat-2:

- is a follow-on mission to Resourcesat-1 and the eighteenth Remote Sensing satellite built by ISRO.
- RESOURCESAT-2 is intended to continue the remote sensing data services to global users provided by RESOURCESAT-1, and to provide data with enhanced multispectral and spatial coverage as well.
- The satellite contains 3 multispectral cameras on board. Advanced Wide-Field Sensor (AWiFS) with 56 meter spatial resolution. The Linear Imaging Self-Scanning Sensor (LISS-III) with 23.5 meter spatial resolution and LISS-IV Camera with 5.8 meter spatial resolution.

Youth sat:

- This satellite was built jointly by India and Russia and has 3 payloads one from Russia and two from India.
- It can be used to study the solar rays, X rays, (Gamma) γ rays etc and also the influence of the sun on the upper layers of the earth.

X-Sat:

- It is the first indigenous remote sensing satellite from Singapore, built by Nanyang technological university.
- It contains 3 payloads for remote sensing operations.
- With the launch of X-Sat India again proved its commercial services in launching foreign satellites.

Cartosat-2B:

- Weight- 694Kg.
- Launched into polar sun synchronous orbit.
- It is the latest in Indian remote sensing.
- It is an earth observing satellite containing a panchromatic camera capable of taking pictures in the visible region of electromagnetic spectrum.
- Useful for village level resources.
- Main applications are mapping and management.
- Preparation of micro water shed development plans
- Monitoring the development works of villages.
- Urban infrastructure planning and development.
- Transportation system planning.
- It works for a period of 5 years.
- The resolution of Cartosat-2B is very high when compared to the earlier Cartosat-1 and Cartosat-2A.

Alsat:

- 116 Kg Alsat is also a remote sensing satellite for the development of rural and urban infrastructure in Algeria.

Studsat:

- It is a satellite developed for the 6 engineering college students in AP& Karnataka.
- Weighs less than 1Kg and demonstrates the achievements of college level human resources available in the country.
- This satellite is mainly intended to test new technologies.

2 nano satellites NLS 6.1 & 6.2 of Switzerland, Canada and a pico satellite called ocean sat-2 were also launched in this mission.

Chandrayaan-1

- It is India's first unmanned lunar probe.
- It was launched by the Indian Space Research Organisation in October 2008, and operated until August 2009.
- The mission included a lunar orbiter and an impactor.
- India launched the spacecraft with a modified version of the PSLV, PSLV C11 on 22 October 2008 from Satish Dhawan Space Centre, Sriharikota.
- The mission was a major boost to India's space program, as India researched and developed its own technology in order to explore the Moon. The vehicle was successfully inserted into lunar orbit on 8 November 2008.
- On 14 November 2008, the Moon Impact Probe separated from the Chandrayaan orbiter at 20:06 and struck the south pole in a controlled manner, making India the fourth country to place its flag on the Moon.
- Over a two-year period, it was intended to survey the lunar surface to produce a complete map of its chemical characteristics and three-dimensional topography. The polar regions are of special interest as they might contain ice.

- Chandrayaan operated for 312 days as opposed to the intended two years but the mission achieved 95 percent of its planned objectives. Among its many achievements was the discovery of the widespread presence of water molecules in lunar soil.

Objectives

The mission had the following stated scientific objectives:

- to design, develop, launch and orbit a spacecraft around the Moon using an Indian-made launch-vehicle
- to conduct scientific experiments using instruments on the spacecraft which would yield data:
    - for the preparation of a three-dimensional atlas (with high spatial and altitude resolution of 5–10 m) of both the near and far sides of the Moon
    - for chemical and mineralogical mapping of the entire lunar surface at high spatial resolution, mapping particularly the chemical elements magnesium, aluminium, silicon, calcium, iron, titanium, radon, uranium, and thorium
    - to increase scientific knowledge
    - to test the impact of a sub-satellite (Moon Impact Probe — MIP) on the surface on the Moon as a fore-runner to future soft-landing missions

Payload

The scientific payload had a total mass of 90 kg and contained five Indian instruments and six foreign instruments.

- **TMC** or the **Terrain Mapping Camera** The aim of this instrument was to completely map the topography of the Moon.
- **HySI** or **Hyper Spectral Imager** performed mineralogical mapping
- **LLRI** or **Lunar Laser Ranging Instrument** determines the height of the surface topography by sending pulses of infrared laser light towards the lunar surface and detecting the reflected portion of that light.
- **HEX** is a **High Energy aj/gamma x-ray spectrometer** the HEX measured U, Th, ^{210}Pb, ^{222}Rn degassing, and other radioactive elements.
- **MIP** or the **Moon Impact Probe** developed by the ISRO, is an impact probe which consisted of a C-band Radar altimeter for measurement of altitude of the probe, a video imaging system for acquiring images of the lunar surface and a mass spectrometer for measuring the constituents of the lunar atmosphere.
- **C1XS** or **X-ray fluorescence spectrometer** mapped the abundance of Mg, Al, Si, Ca, Ti, and Fe.
- **Atom Reflecting Analyser** from the ESA mapped mineral composition using low energy neutral atoms emitted from the surface.
- **M^3**, the **Moon Mineralogy Mapper** is an imaging spectrometer designed to map the surface mineral composition.
- **SIR-2**, A near infrared spectrometer from ESA,
- **RADOM-7**, **Radiation Dose Monitor Experiment** from the Bulgarian Academy of Sciences maps the radiation environment around the Moon. It was successfully tested on 16 November 2008.

1. MARS ORBITOR MISSION

The MOM mission is a "technology demonstrator" project aiming to develop the technologies required for design, planning, management and operations of an interplanetary mission.

If successful, Indian Space Research Organisation (ISRO) would be the fourth space agency to reach Mars after Roscosmos, NASA and ESA. The project was approved by the government of India on 3 August 2012, and may cost up to INR4.54 billion (US$69 million).

1. The primary objective of the mission is to display India's rocket launch systems, spacecraft-building and operations capabilities.
2. The main theme of MOM appears to be to seek whether there is methane, considered a "precursor chemical" for life, on the Red Planet.
3. The satellite will carry compact science experiment instruments, totalling a mass of 15kg to study Martian surface, atmosphere and mineralogy.
4. The 15 kg scientific payload consists of five instruments:

   Atmospheric studies

   Lyman-Alpha Photometer (LAP) – is a photometer that measures the relative abundance of deuterium and hydrogen from Lyman-alpha emissions in the upper atmosphere.

   Methane Sensor For Mars (MSM) – will look to detect the presence of methane in the atmosphere of Mars.

   Particle environment studies

   Mars Exospheric Neutral Composition Analyzer (MENCA) - is a quadrupole mass analyzer capable of analyzing the neutral composition of particles in the exosphere.

   Surface imaging studies

   Thermal Infrared Imaging Spectrometer (TIS) - will measure the temperature and emissivity of the Martian surface, this can allow mapping surface composition and mineralogy of Mars.

   Mars Colour Camera (MCC) - will provide images in the visual spectrum, providing context information for the other science instruments.

2. CHANDRAYAAN-2

Chandrayaan-2: is India's second lunar exploration mission. Developed by the Indian Space Research Organisation (ISRO), the mission is proposed to be launched to the Moon by a Geosynchronous Satellite Launch Vehicle (GSLV),includes a lunar orbiter, a lander and a lunar rover, all developed by India. According to ISRO, this mission will use and test various new technologies and conduct new experiments. The wheeled rover will move on the lunar surface and will pick up soil or rock samples for on-site chemical analysis. The data will be relayed to Earth through the Chandrayaan-2 orbiter. Initially the mission was a joint venture of ISRO and its Russian counterpart Roscosmos, but the latter withdrew from the mission failing to provide a lander within the proposed time. There is no time frame set for the mission.

History

Roscosmos was to provide lander but the loss of the Fobos-Grunt mission (a mission on to the moon of mars) which was a planned as a test for the Russian landing system made Russia to with draw from the mission

Design

Orbiter: ISRO will design the orbiter, which will orbit the Moon at an altitude of 200 km. The mission would carry five instruments on the orbiter. Three of them are new, while two others are improved versions of those flown on Chandrayaan-1 orbiter. The approximate launch mass will be 1,400 kg.

Lander: Unlike Chandrayaan-1's lunar probe, which impacted the Moon's surface, the lander will make a soft landing. The approximate weight of the lander and rover is 1,250 kg. Initially, the design of the indigenous lander and the preliminary configuration study has been completed by the Space Applications Centre (SAC) in Ahmedabad.

Rover: The rover will weigh 30–100 kg and will operate on solar power. The rover will move on wheels on the lunar surface, pick up samples of soil or rocks, perform chemical analysis and send the data to the orbiter above, which will relay it to the Earth station.

The rover has been designed in Russia and is being fabricated by Indian scientists. IIT Kanpur is developing three subsystems to provide mobility:

Payload

ISRO has announced that an expert committee has decided on five payloads for the orbiter, and two for the rover. While it was initially reported that NASA and ESA would participate in the mission by providing some scientific instruments for the orbiter, ISRO has later clarified that due to weight restrictions it will not be carrying foreign payloads on this mission.

Orbiter payload

- Large Area Soft X-ray Spectrometer (CLASS) from ISRO Satellite Centre (ISAC),
- Synthetic Aperture Radar (SAR) from Space Applications Centre (SAC), Ahmedabad for probing the first few tens of metres of the lunar surface for the presence of different constituents, including water ice.
- Imaging IR Spectrometer (IIRS) from SAC, Ahmedabad for mapping of lunar surface over a wide wavelength range for the study of minerals, water molecules and hydroxyl present.
- Neutral Mass Spectrometer from Space Physics Laboratory (SPL), Thiruvananthapuram to carry out a detailed study of the lunar exosphere.
- Terrain Mapping Camera-2 (TMC-2) from SAC, Ahmedabad for preparing a three-dimensional map essential for studying the lunar mineralogy and geology.

Rover payload

- Laser induced Breakdown Spectroscope (LIBS) from Laboratory for Electro Optic Systems (LEOS), Bangalore.
- Alpha Particle Induced X-ray Spectroscope (APIXS) from PRL, Ahmedabad.

Later there were reports of plans to send a seismometer to moon to study about moon-quakes.

3. NASA's IRIS Mission

- It is a space probe to observe the Sun by NASA.
- The Interface Region Imaging Spectrograph, or IRIS, is launched from Vandenberg Air Force Base.
- IRIS will advance our understanding of the interface region, a region in the lower atmosphere of the sun where most of the sun's ultraviolet emissions are generated. Such emissions impact the near-Earth space environment and Earth's climate.
- IRIS will orbit Earth and use its ultraviolet telescope to obtain high-resolution solar images and spectra. IRIS observations along with advanced computer models will deepen our understanding of how heat and energy move through the lower atmosphere of the sun and other sun-like stars.

The search for dark matter

- The mysterious dark matter, which is believed to account for a quarter of the universe's mass-energy balance, can be observed indirectly through its gravitational interaction with visible matter but is yet to be directly detected.
- The search for dark matter is one of the objectives of the space-borne AMS (Alpha magnetic spectrometer).
- The dark matter is also being actively searched for in ground-based experiments such as the Large Hadron Collider (LHC) and other deep underground experiments.
- The AMS instrument is the most powerful and sensitive particle spectrometer ever deployed in space. It is designed to study the cosmic ray particles, which are charged high-energy particles that permeate space, before they have a chance to interact with the Earth's atmosphere.
- The positron ratio is a key parameter in the search for dark matter. Some theories, such as super symmetry, predict that dark mater particles will collide and annihilate in space, producing an excess of positrons that detectors such as the AMS would be able to detect.