GLIMPSES
OF INDIAN SPACE PROGRAMME

Government of India established the Department of Space in 1972 to promote development and application of space science and technology for socio-economic benefits. Indian Space Research Organisation (ISRO) is the primary agency under the Department of Space for executing space programmes. During the seventies, India undertook demonstration of space applications for communication, broadcasting and remote sensing; designed and built experimental satellites – Aryabhata, Bhaskara, APPLE and Rohini – and experimental Satellite Launch Vehicles – SLV-3 and ASLV. Today, India has established space systems that form an important element of the national infrastructure. India successfully sent its Chandrayaan-1 spacecraft to moon in November 2008 and became the fourth individual country to send a probe to the lunar surface. India's 100th Space Mission took place in September 2012 during which the country's workhorse Polar Satellite Launch Vehicle (PSLV) successfully placed French SPOT-6 and Japanese PROITERES satelites in the required orbits. In September 2014, India successfully placed an unmanned spacecraft in an orbit around planet Mars.

National Systems using Space Technology

INSAT/GSAT

- Telecommunications
- Broadcasting (TV, Radio)
- Business Communication
- Mobile Communication
- Tele-education
- Telemedicine
- Search & Rescue
- Satellite Navigation
- Meteorology

IRS

- Natural Resources Management
- Natural Resources Information System
  - Water
  - Forest
  - Crop
  - Land
  - Minerals
  - Environment
  - Ocean

Launch Vehicles

GSLV

PSLV

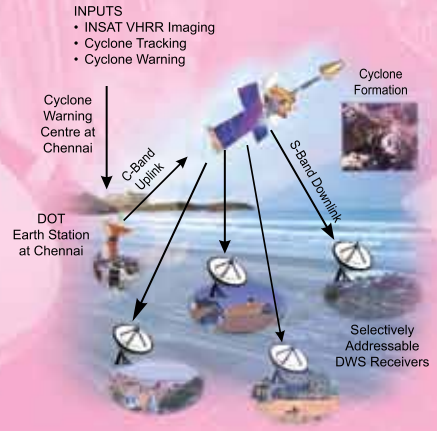
GSLV MkIII

- Disaster Management Support
- e-Governance

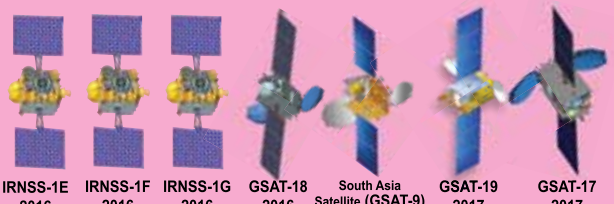
Indian National Satellite (INSAT) System

Commissioned in 1983, INSAT is a multipurpose satellite system for telecommunications, television broadcasting, meteorology, disaster warning and search and rescue. Besides telecommunications and regular broadcasting services, INSAT/GSAT satellite are widely used today for interactive education, developmental communication and telemedicine. Meteorological imaging and direct-to-community broadcast capabilities of INSAT/GSAT help in issuing warnings on impending cyclones. INSAT also carries transponders dedicated to search and rescue operations as part of international COSPAS/SARSAT programme.

Disaster Warning System



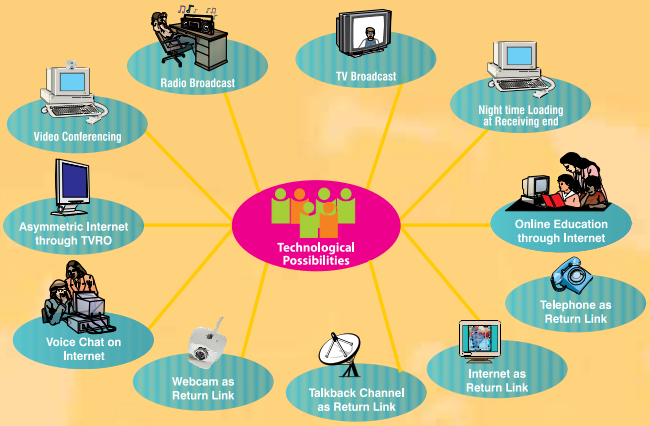
Communication and Navigation Satellites of India



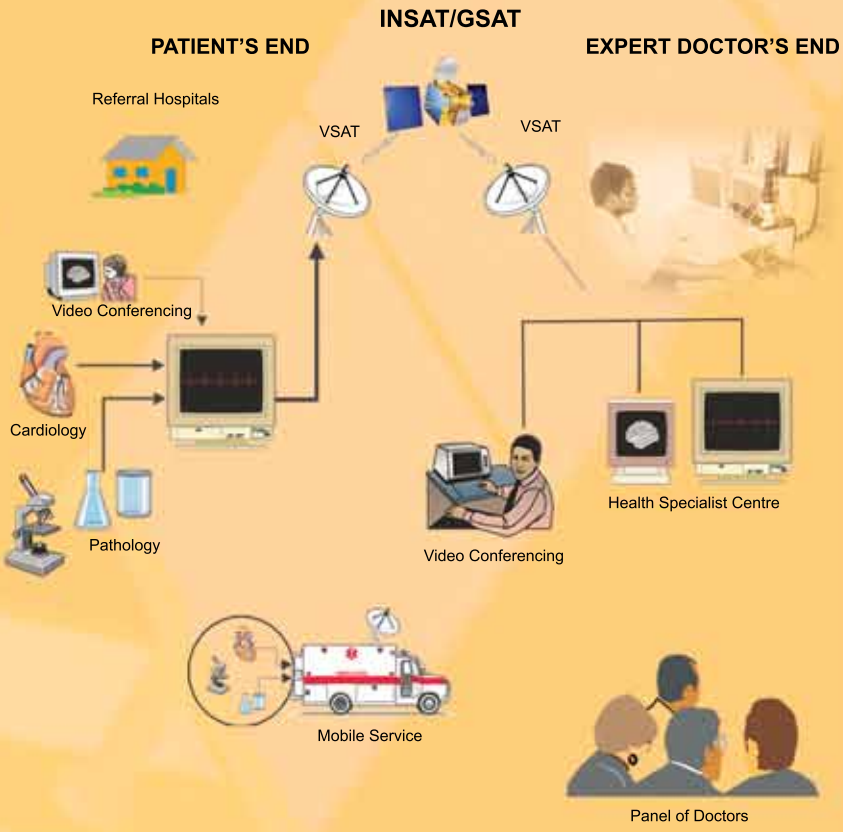
Tele-education

Tele-education programme of ISRO, through INSAT/GSAT series of satellites, supports

- Services through audio-visual medium employing digital interactive classroom multimedia, multi-centric system
- Sustainable Distance Education Service
- School, college and higher levels of education and non-formal education



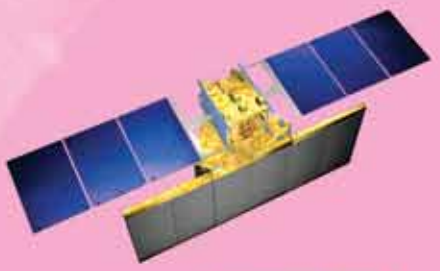
Telemedicine



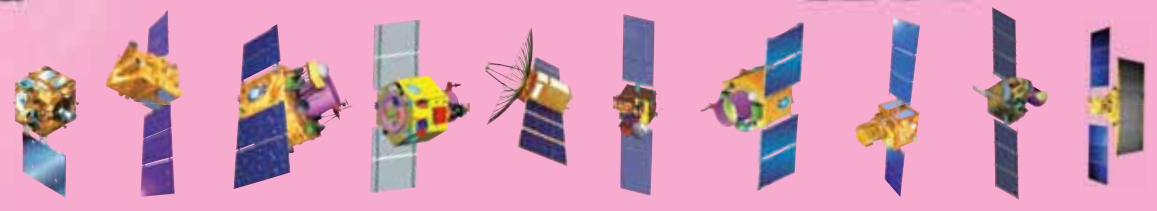
Indian Remote Sensing Satellite (IRS) System

Madurai as seen by Cartosat-2B

Commissioned in 1988, India now has the world's largest constellation of remote sensing satellites. The system offers space-based data in a range of spectral bands, spatial resolutions and swaths. The data is used for several applications covering agriculture, water resources, urban development, mineral prospecting, environment, forestry, drought and flood forecasting, ocean resources and disaster management.



Earth Observation Satellites of India



KALPANA-1 2002 | CARTOSAT-1 2005 | CARTOSAT-2 2007 | CARTOSAT-2A 2008 | RISAT-2 2009 | OCEANSAT-2 2009 | CARTOSAT-2B 2010 | RESOURCESAT-2 2011 | MEGHA-TROPIQUES 2011 | RISAT-1 2012

SARAL 2013 | INSAT-3D 2013 | CARTOSAT-2 Series Satellite 2016 | INSAT-3DR 2016 | SCATSAT-1 2016 | RESOURCESAT-2A 2016 | CARTOSAT-2 Series Satellite February 2017 | CARTOSAT-2 Series Satellite June 2017 | CARTOSAT-2 Series Satellite January 2018

Indian Regional Navigation Satellite System (IRNSS)

IRNSS is an independent regional navigation satellite system being developed by India. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary, which is its primary service area.

The IRNSS System is designed to provide a position accuracy of better than 20 m in the primary service area.

The IRNSS space segment consists of seven satellites, with three satellites in geostationary orbit and four satellites in inclined geosynchronous orbit.

IRNSS-1A, 1B, 1C, 1D, 1E, 1F & 1G, the seven satellites in the IRNSS series, were successfully launched by PSLV on July 02, 2013, April 04, 2014, October 16, 2014, March 28, 2015, Jan 20, 2016, March 10, 2016 and April 28, 2016 respectively.

Space capsule Recovery Experiment (SRE-1)

Space capsule Recovery Experiment (SRE-1) is a 550 kg capsule that demonstrated a host of technologies for orbiting a capsule to perform experiments in microgravity conditions of space, and after completion of the experiments, de-orbit and recover the capsule. All these form the basis for reusable launch vehicles. SRE-1 was launched on January 10, 2007 by PSLV-C7 and twelve days later was successfully recovered over Bay of Bengal.

RLV-TD

SCRAMJET

Sounding Rockets

RH-200 RH-300 RH-300 Mk II RH-560 Mk II

A variety of Rohini sounding rockets have been developed by India for conducting scientific and technological experiments.

Launch Vehicles

India has developed and commissioned Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV MkII and MkIII). PSLV can launch 1850 kg class remote sensing satellites into a 480 km polar Orbit.

It can also place a satellite weighing about 1200 kg in Geosynchronous Transfer Orbit (GTO) or a 3500 kg class satellite in Low Earth Orbit.

GSLV MkII, equipped with indigenously developed C12 Cryogenic Upper Stage, is capable of launching 2000 kg class of satellites into GTO. GSLV MkIII, capable of placing 4000 kg class satellites in GTO, had its first experimental suborbital flight (LVM3-X/CARE) in December 2014. The 3775 kg Crew Module Atmospheric Re-entry Experiment (CARE) carried on-board LVM3-X to a height of 126 km, later safely landed over Andaman sea with the help of its parachutes and successfully recovered.

GSLV MkIII-D1, the first developmental (orbital) flight of GSLV MkIII with the indigenous C25 cryogenic upper stage took place in June 2017. The vehicle launched 3136 kg GSAT-19 to GTO successfully.

Reusable Launch Vehicle - Technology Demonstrator (RLV-TD), the subscale version of India's proposed RLV, had its first experimental test flight on May 23, 2016. And, ISRO's SCRAMJET engine technology demonstrator was successfully flight tested on August 28, 2016.

Static test of LVM-3 S200 strap-on booster

Static Test of LVM-3 L110 Liquid Core Stage

Space Sciences

ASTROSAT

Full disc Image of Mars sent by Mars Orbiter Spacecraft

Mars Orbiter Mission

India has flown Gamma-Ray and Retarding Potential Analyser payloads on two of its Stretched Rohini Satellites launched in 1992 and 1994. IRS-P3, launched in 1996, carried an X-ray astronomy payload.

Chandrayaan-1, India's first spacecraft mission to moon, was successfully launched by PSLV-C11 on October 22, 2008 into an Earth orbit. Carrying 11 payloads built in India and abroad, the spacecraft later reached the moon and went into an orbit around it with the help of its Liquid Apogee Motor. After reaching its final operational orbit of 100 km height from the lunar surface, the spacecraft's Moon Impact Probe separated and successfully reached the lunar surface 25 minutes later, carrying Indian tricolour with it on November 14, 2008. *During its active life, Chandrayaan-1 spacecraft conclusively found the presence of water molecules on the moon.*

In 2011, PSLV launched Youthsat, a scientific satellite built by ISRO carrying Indian and Russian payloads for Solar and Atmospheric Studies, into orbit.

India's Mars Orbiter Mission envisages the exploration of Planet Mars through a spacecraft orbiting that planet. The 1340 kg Mars Orbiter Spacecraft was launched by PSLV during its twenty fifth flight (PSLV-C25) on November 05, 2013, into an elliptical Earth parking orbit.

Later, the spacecraft's Liquid Engine (LAM) was used to raise the orbit of the spacecraft as well as to place it in 'Mars Transfer Trajectory'. The spacecraft, carrying five payloads - Mars Colour Camera, Thermal Infrared Imaging spectrometer, Methane Sensor for Mars, Lyman Alpha Photometer and Mars Exospheric Neutral Composition Analyser - safely covered a total travel distance of 667 million km to Mars and on September 24, 2014 sucessfully entered into a 422 x 77,000 km orbit around that planet. On September 24, 2017, the spacecraft successfully completed three years in its Mars orbit.

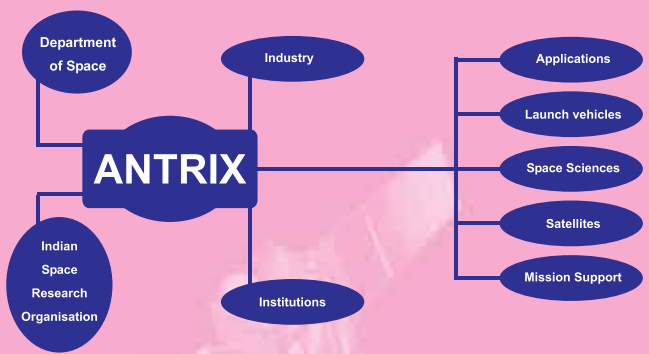
ASTROSAT, India's first multi wavelength space observatory, launched in 2015, successfully completed two years in orbit on September 28, 2017. Chandrayaan-2, carrying an orbiter, lander and rover is planned to be launched by GSLV. A solar observation spacecraft, ADITYA-L1, is also planned. Several ground-based facilities for space sciences, including a Mesosphere Stratosphere Troposphere (MST) Radar, have been set up in India.

Infrastructure for Space Development

India has established a strong infrastructure for realising its space programme. They include facilities for the development of satellites and launch vehicles and their testing; launch infrastructure for sounding rockets and satellite launch vehicles; telemetry, tracking and command network; data reception and processing systems for remote sensing. A number of academic and research institutions as well as industries participate in the Indian Space Programme. Several Indian industries have the expertise to undertake sophisticated jobs required for space systems.

A panoramic view of the First and Second Launch Pads at Satish Dhawan Space Centre SHAR, Sriharikota

Space Services from India

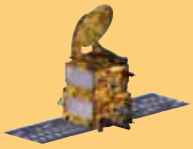


Antrix Corporation Limited is the commercial arm of the Department of Space, with access to the resources of DOS as well as Indian space industries. Antrix markets subsystems and components for satellites, undertakes contracts for building satellites to user specifications, provides launch services and tracking facilities and organises training of manpower and software development. By January 2018, Antrix had facilitated the launch of 237 foreign customer satellites in PSLV.

International Co-operation

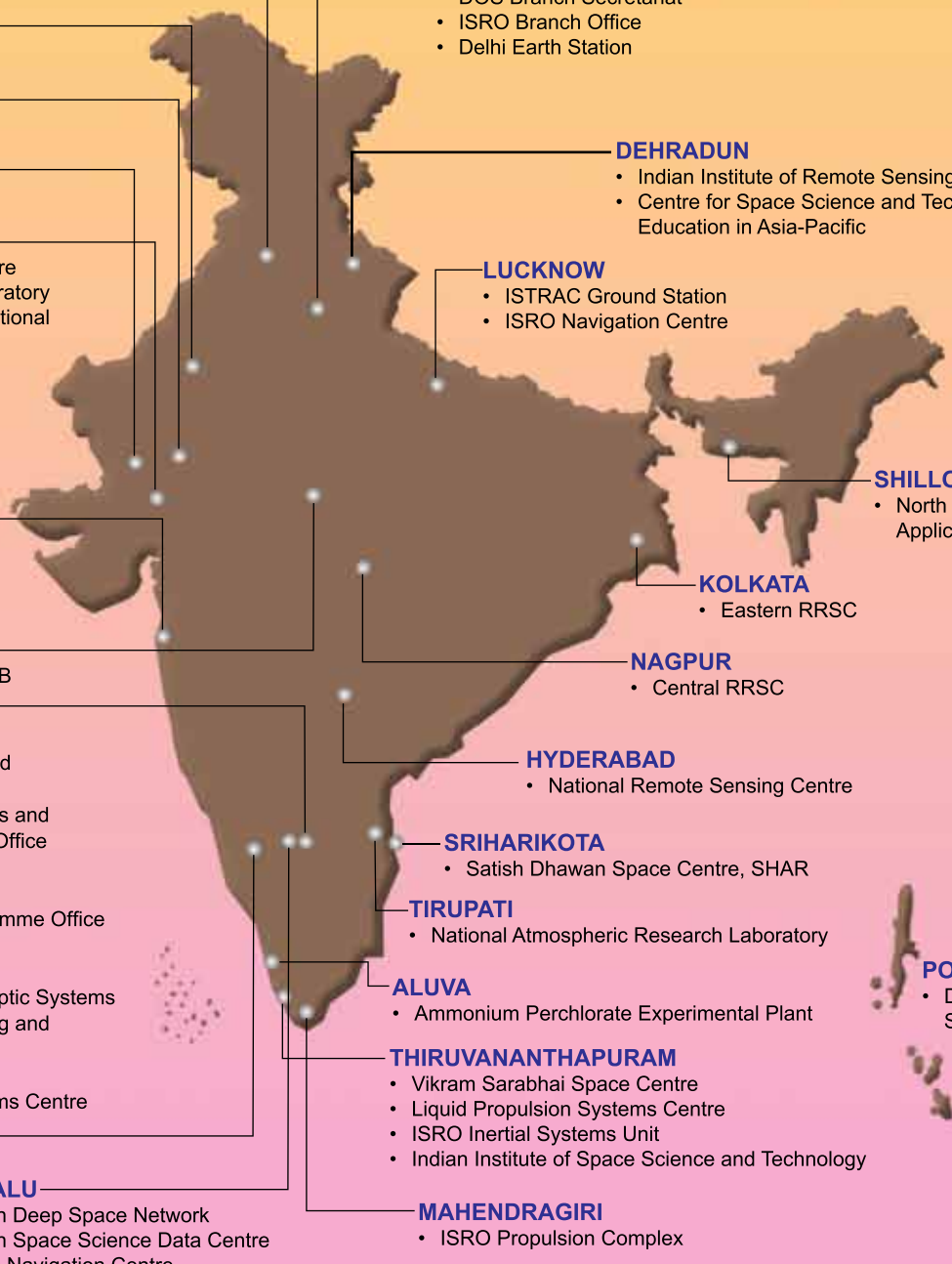
International co-operation has been the hallmark of Indian space programme. India participates in major space fora including the UN, IAF, COSPAR and CEOS. India has set up the *Centre for Space Science and Technology Education in Asia and the Pacific* (CSSTE-AP) which is sponsored by the United Nations. India offers training in space applications to personnel from developing countries under the programme *Sharing of Experience in Space* (SHARES). Chandrayaan-1, a 1400 kg unmanned spacecraft built by ISRO for exploring the moon, carried 11 scientific instruments from India, the United States, the European Space Agency and Bulgaria. Youthsat, an Indo-Russian scientific satellite, was successfully launched onboard PSLV in 2011. Megha-Tropiques, a joint Indo-French satellite mission for the study of tropical atmosphere and SARAL, another joint Indo-French satellite mission for ocean studies, were successfully launched by PSLV in 2011 and 2013 respectively. ISRO and NASA are now jointly endeavouring to realise the microwave remote sensing satellite "NISAR".

MEGHA-TROPIQUES



SARAL

Space Centres in India



CHANDIGARH
- Semi-Conductor Laboratory

JODHPUR
- Western RRSC

UDAIPUR
- Solar Observatory

Mt. ABU
- Infrared Observatory

AHMEDABAD
- Space Applications Centre
- Physical Research Laboratory
- Development and Educational Communication Unit

MUMBAI
- ISRO Liaison Office

BHOPAL
- Master Control Facility - B

BENGALURU
- Space Commission
- Department of Space and ISRO Headquarters
- Satellite Communications and Navigation Programme Office
- NNRMS Secretariat
- ADCOS Secretariat
- Civil Engineering Programme Office
- Antrix Corporation
- ISRO Satellite Centre
- Laboratory for Electro-Optic Systems
- ISRO Telemetry, Tracking and Command Network
- Southern RRSC
- Liquid Propulsion Systems Centre

HASSAN
- Master Control Facility

BYALALU
- Indian Deep Space Network
- Indian Space Science Data Centre
- ISRO Navigation Centre

NEW DELHI
- DOS Branch Secretariat
- ISRO Branch Office
- Delhi Earth Station

DEHRADUN
- Indian Institute of Remote Sensing
- Centre for Space Science and Technology Education in Asia-Pacific

LUCKNOW
- ISTRAC Ground Station
- ISRO Navigation Centre

SHILLONG
- North Eastern-Space Applications Centre

KOLKATA
- Eastern RRSC

NAGPUR
- Central RRSC

HYDERABAD
- National Remote Sensing Centre

SRIHARIKOTA
- Satish Dhawan Space Centre, SHAR

TIRUPATI
- National Atmospheric Research Laboratory

ALUVA
- Ammonium Perchlorate Experimental Plant

THIRUVANANTHAPURAM
- Vikram Sarabhai Space Centre
- Liquid Propulsion Systems Centre
- ISRO Inertial Systems Unit
- Indian Institute of Space Science and Technology

MAHENDRAGIRI
- ISRO Propulsion Complex

PORT BLAIR
- Down Range Station

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