UNIT-V

Remote Sensing in India

ISRO (Indian Space Research Organisation)

The **Indian Space Research Organisation** is the national space agency of the Republic of India, headquartered in Bengaluru. It operates under Department of Space (DoS) which is directly overseen by the prime minister of India while chairman of ISRO acts as executive of DoS as well. ISRO is the primary agency in India to perform tasks related to space based applications, space exploration and development of related technologies. It is one of six government space agencies in the world which possess full launch capabilities, deploy cryogenic engines, launch extraterrestrial missions and operate large fleets of artificial satellites.

The Indian National Committee for Space Research (INCOSPAR) was established by Jawaharlal Nehru under the Department of Atomic Energy (DAE) in 1962, with the urging of scientist Vikram Sarabhai recognising the need in space research. INCOSPAR grew and became ISRO in 1969, also under the DAE. In 1972, the Government of India had set up a Space Commission and the Department of Space (DOS),[12] bringing ISRO under the DOS. The establishment of ISRO thus institutionalised space research activities in India. It is managed by the DOS, which reports to the Prime Minister of India.

ISRO built India's first satellite, Aryabhata, which was launched by the Soviet Union on 19 April 1975. It was named after the mathematician Aryabhata. In 1980, Rohini became the first satellite to be placed in orbit by an Indian-made launch vehicle, SLV-3. ISRO subsequently developed two other rockets: the Polar Satellite Launch Vehicle (PSLV) for launching satellites into polar orbits and the Geosynchronous Satellite Launch Vehicle (GSLV) for placing satellites into geostationary orbits. These rockets have launched numerous communications satellites and Earth observation satellites. Satellite navigation systems like GAGAN and IRNSS have been deployed. In January 2014, ISRO used an indigenous cryogenic engine CE-7.5 in a GSLV-D5 launch of the GSAT-14.

ISRO sent a lunar orbiter, Chandrayaan-1, on 22 October 2008, which discovered lunar water in the form of ice, and the Mars Orbiter Mission, on 5 November 2013, which entered Mars orbit on 24 September 2014, making India the first nation to succeed on its maiden attempt to Mars, as well as the first space agency in Asia to reach Mars orbit. On 18 June 2016, ISRO launched twenty satellites in a single vehicle, and on 15 February 2017, ISRO launched one hundred and four satellites in a single rocket (PSLV-C37), a world record. ISRO launched its heaviest rocket, Geosynchronous Satellite Launch Vehicle-Mark III (GSLV-Mk III), on 5 June 2017 and placed a communications satellite GSAT-19 in orbit. With this launch, ISRO became capable of launching 4-tonne heavy satellites into GTO. On 22 July 2019, ISRO launched its second lunar mission Chandrayaan-2 to study the lunar geology and the distribution of lunar water.

Future plans include development of the Unified Launch Vehicle, Small Satellite Launch Vehicle, development of a reusable launch vehicle, human spaceflight, a space station, interplanetary probes, and a solar spacecraft mission.

NRSC

National Remote Sensing Centre (NRSC) at Hyderabad has been converted into a full-fledged centres of ISRO since September 1, 2008. Earlier, NRSC was an

autonomous body called National Remote Sensing Agency (NRSA) under Department of Space (DOS). The Centre is responsible for remote sensing satellite data acquisition and processing, data dissemination, aerial remote sensing and decision support for disaster management.

NRSC has a data reception station at Shadnagar near Hyderabad for acquiring data from Indian remote sensing satellites as well as others.

NRSC Ground station at Shadnagar acquires Earth Observation data from Indian remote-sensing satellites as well as from different foreign satellites. NRSC is also engaged in executing remote sensing application projects in collaboration with the users. The Aerial Services and Digital Mapping (ASDM) Area provides end-to-end Aerial Remote Sensing services and value-added solutions for various large scale applications like aerial photography and digital mapping, infrastructure planning, scanner surveys, aeromagnetic surveys, large scale base map, topographic and cadastral level mapping, etc.

Regional Remote Sensing Centres (RRSCs) support various remote sensing tasks specific to their regions as well as at the national level. RRSCs are carrying out application projects encompassing all the fields of natural resources. RRSCs are also, involved in software development, customisation and packaging specific to user requirements and conducting regular training programmes for users in geo-spatial technology, particularly digital image processing and Geographical Information System (GIS) applications.

IRS Satellites

IRS Satellites Series

Serial No.	Satellite	Date of Launch	Launch Vehicle	Status	Applications
1	IRS-1A	17 March 1988	Vostok, USSR	Mission Completed	Land Use Land Cover Mapping, Agriculture, Forestry, Hydrology, Soil Classification, Coastal Wetland Mapping, Natural Resources (especially identification of potential groundwater 2 locations), Disaster Monitoring, Cartography, etc.
2	IRS-1B	29 August 1991	Vostok, USSR	Mission Completed	
3	IRS-P1 (also IE)	20 September 1993	PSLV-D1	Crashed, due to launch failure of PSLV	Mission Failed
4	IRS-P2	15 October 1994	PSLV-D2	Mission Completed	Land, Oceanographic and Atmospheric applications

5	IRS-1C	28 December 1995	Molniya, Russia	Mission Completed	Technology Evaluation and Scientific Methodology Studies
6	IRS-P3	21 March 1996	PSLV-D3	Mission Completed	Land and water resources management. Applications in forestry, agriculture, environment, soil characteristics, wasteland identification, flood and drought monitoring, ocean resource development, mineral exploration, land use and monitoring of underground and surface water resources.
7	IRS 1D	29 September 1997	PSLV-C1	Mission Completed	
8	IRS-P4 (Oceansat-1)	27 May 1999	PSLV-C2	Mission Completed	Ocean- and atmosphere-related applications
9	Technology Experiment Satellite (TES)	22 October 2001	PSLV-C3	Mission Completed	Experimental satellite to demonstrate and validate the technologies
10	IRS P6 (Resourcesat-1)	17 October 2003	PSLV-C5	In Service	Integrated land and water resources management
11	IRS P5 (Cartosat 1)	5 May 2005	PSLV-C6	In Service	First Indian Satellite (IRS P5) designed with capability to have stereo images;
12	IRS P7 (Cartosat 2)	10 January 2007	PSLV-C7	In Service	Digital Elevation Model (DEM); Geo-engineering (mapping) applications
13	Cartosat 2A	28 April 2008	PSLV-C9	In Service	DO
14	IMS 1	28 April 2008	PSLV-C9	In Service	To provide remotely sensed data to students and scientists in developing counties,
15	RISAT-2	20 April 2009	PSLV-C12	In Service	Ocean and atmosphere-related applications
16	Oceansat-2	23 September 2009	PSLV-C14	In Service	Gep-engineering (mapping) applications

17	Cartosat-2B	12 July 2010	PSLV-C15	In Service	Integrated land and water resources management
18	Resourcesat-2	20 April 2011	PSLV-C16	In Service	To understand the tropical weather and climate and associated energy and moisture budget
19	Megha-Tropiques	12 October 2011	PSLV-C18	In Service	In agriculture, especially paddy monitoring in Kharif season
20	RISAT-1	26 April 2012	PSLV-C19	In Service	Marine meteorology and sea state forecasting; seasonal forecasting; climate
21	SARAL	25 Feb 2013	PSLV-C20	In Service	Integrated land and water resources management
22	Cartosat-2C	22 June 2016	PSLV-C34	In Service	Cartographic applications, urban and rural applications, coastal land use and regulation, utility management like road network monitoring, water distribution and creation of land use maps. Change detection to bring out geographical and manmade features and various other Land Information System (LIS) as well as Geographical Information System (GIS) applications.
23	ScatSat-1	26 September 2016	PSLV-C35	In Service	Weather prediction
24	RESOURCESAT-2A	07 Dec 2016	PSLV-C36	In Service	Earth observation, satellite communication, disaster management support
25	Cartosat-2D	15 Feb 2017	PSLV-C37	In Service	Generation of imagery for cartography, environmental monitoring, disaster relief and event monitoring
26	Cartosat-2E	23 June 2017	PSLV-C38	In Service	The imagery sent by satellite will be useful for cartographic applications, urban and rural applications, coastal land use and regulation, utility management like road network

					monitoring, water distribution, creation of land use maps, change detection to bring out geographical and manmade features and various other Land Information System (LIS) as well as Geographical Information System (GIS) applications.
27	Cartosat-2F	12 Jan 2018	PSLV-C40	In Service	The data from the satellite will be used for detailed mapping and other cartographic applications at cadastral level, urban and rural infrastructure development and management, as well as applications in Land Information System (LIS) and Geographical Information System (GIS).
28	RISAT-2B	22 May 2019	PSLV-C46	In Service	Disaster management an earth observation
29	Cartosat-3	27 Nov 2019	PSLV-C47	In Service	The satellite will be used for a variety of earth-observation **applications**, such as cartography, weather mapping, forest surveys, urban planning, coastal studies, mineral prospecting, and, of course, military purposes.
30	RISAT-2BR1	11 Dec 2019	PSLV-C48	In Service	Agriculture, forestry and disaster management

Characteristics of IRS Satellites

Satellite	**Sensor**	**Spectral Resolution (mm)**	**Spatial Resolution (mm)**	**Wath Width (km)**	**Temporal Resolution (days)**	**Orbit characteristics and Radiometric Resolution or Quantization Level**
IRS-1A/1B	LISS-I, and LISS-II A/B (sensors)	0.45-0.52 0.52-0.59 0.62-0.68 0.77-0.86	72.5m LISS-I 36m LISS-II	148 74x2	22	Orbit-Sun-synchronous; Altitude-904km;Inclination-99.5^0; Equatorial crossing-10.26 a.m.; Orbit Period-103.2 minutes. Radimetric resolution-7 bit;
IRS-1C/1D	LISS-III	0.52-0.59 0.62-0.68	23.5 23.5	142 142	24	Orbit-Sun-synchronous, Altitude-904km; Inclination-98.69^0;

		0.77-0.86 1.55-1.70	23.5 70	142 148		Equatorial crossing-10.30a.m. Orbit period-101.23 minutes; Radiometric Resolution-7 bit, Pan-6 bit
	PAN	0.50-0.75	5.8	70	24 (5)	
	WiFS	0.62-0.68 0.77-0.86	188	804	5	
IRS-P3	WiFS	0.62-0.68 0.77-0.86 1.55-1.70	188	804	5	Orbit: Sun-synchronous; Equatorial crossing at 10.30 a.m, Altitude=817 km; Inclination=98.7^0;mOrbit Period period=101.35 minutes; Radiometric resolution-7 bit
	MOS-A MOS-B MOS-C	0.75-0.77 0.41-1.01 1.595-1.605	1500 520 550	195 200 192	24	
IRS-P4(Oceansat-1)	OCM MSMR	0.4-0.9 6.6, 10.65, 18, 21 GHz (freq.)	360x236 105x68, 66x43, 40x26, 34x22	1420 1360	2 2	Orbit: Sun-synchronous; Altitude = 720 km; Inclination = 98.28º; Orbit Period = 99.31 min; Equator crossing at 12:00; Spatial Resolution in km for frequency sequence; Radiometric Resolution – 12 bit.
IRS-P6 ResourceSat1	LISS-IV	0.52-0.59 0.62-0.68 0.77-0.86	5.8 5.8 5.8	70	24(5)	Orbit - Sun-synchronous Altitude = 817 km, Inclination = 98.69º, Orbit Period = 101.35 min; Equator crossing at 10:30 a.m. Radiometric Resolution – 10 bit
	LISS-III	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70	23.5 23.5 23.5 23.5	140	24	
	AWiFS	0.62-0.68 0.77-0.86 1.55-1.70	56-70 56-70 56-70	740	5	
IRS-P5 CartoSat-1	PAN-F PAN-A	0.50-0.75 0.50-0.75	2.5 2.5	30 30		Orbit - Sun-synchronous ; Altitude = 618 km; Inclination =97.87º; Orbit Period of 97 min; Equatorial crossing - 10:30 a.m. Radiometric Resolution – 10 bi

Recent Development of Remote Sensing in India

CARTOSAT

The Cartosat satellites are a series of Indian optical earth observation satellites built and operated by the Indian Space Research Organisation (ISRO). The Cartosat series is a part of the Indian Remote Sensing Program. They are used for Earth's resource management,defence services and monitoring.

Cartosat-1

Cartosat-1 was launched by PSLV-C6 on 5 May 2005 from Satish Dhawan Space Centre's SLP at Sriharikota. Images from the satellite are available from GeoEye for worldwide distribution. The satellite covers the entire globe in 1867 orbits on a 126-day cycle. It carries two state-of-the-art panchromatic (PAN) cameras that take black and white stereoscopic pictures of the earth in the visible region of the electromagnetic spectrum. The two cameras with 2.5 m spatial resolution, acquire two images simultaneously, one forward looking (FORE) at +26 degrees and one aft of the satellite at −5 degrees for near instantaneous stereo data. The time difference between the acquisitions of the same scene by the two cameras is about 52 seconds.

Cartosat-2

Cartosat-2 was launched by PSLV-C7 on 10 January 2007 from Satish Dhawan Space Centre's FLP at Sriharikota. Cartosat-2 carries a state-of-the-art panchromatic (PAN) camera that take black and white pictures of the earth in the visible region of the electromagnetic spectrum. The swath covered by this high resolution PAN camera is 9.6 km and their spatial resolution is less than 1 metre. The satellite can be steered up to 45 degrees along as well as across the track. Cartosat-2 is an advanced remote sensing satellite capable of providing scene-specific spot imagery. The data from the satellite is used for detailed mapping and other cartographic applications at cad-astral level, urban and rural infrastructure development and management, as well as applications in Land Information System (LIS) and Geographical Information System (GIS).

Cartosat-2A

Cartosat-2A was launched by PSLV-C9 on 28 April 2008 from Satish Dhawan Space Centre in Sriharikota along with 9 other satellites. It is a dedicated satellite for the Indian Armed Forces which is in the process of establishing an Aerospace Command. The satellite carries a panchromatic (PAN) camera capable of taking black-and-white pictures in the visible region of electromagnetic spectrum. The highly agile Cartosat-2A can be steered up to 45 degrees along as well as across the direction of its movement to facilitate imaging of any area more frequently.

Cartosat-2B

Cartosat-2B was launched by PSLV-C15 on 12 July 2010 from Sriharikota. The satellite carries a panchromatic (PAN) camera capable of taking black-and-white pictures in the visible region of electromagnetic spectrum. The highly agile CARTOSAT-2B can be

steered up to 26 degrees along as well as across the direction of its movement to facilitate imaging of any area more frequently.

Cartosat-2C

Cartosat-2C has a lower resolution of 25 cm (10"). It uses 1.2 m optics with 60% of weight removal compared to Cartosat-2. Other features include the use of adaptive optics, acousto optical devices, in-orbit focusing using MEMs and large area-light weight mirrors. The satellite was to be launched on board PSLV C-34 during 2014, but was delayed and finally launched on 22 June 2016. Its uses include weather mapping, cartography, and strategic applications.

Cartosat-2D

Cartosat-2D was launched by PSLV-C37 on 15 February 2017 from Satish Dhawan Space Centre.

Cartosat-2E

Cartosat-2E was launched by PSLV-C38 on 23 June 2017. The PSLV-C38 rocket launched the 712 kg satellite along with 30 other nano satellites.

Cartosat-2F

Cartosat-2F was launched successfully by PSLV-C40 on 12 January 2018. The PSLV-C40 rocket launched the 710 kg satellite, the seventh of the Cartosat-2 series, along with 30 other nano satellites from India, Canada, Finland, France, Republic of Korea, UK and the USA.

Cartosat-3

Cartosat-3 was launched on 27 November 2019 by PSLV-C47 rocket along with 13 other cubesats from USA. It has a panchromatic resolution of 0.25 metres making it the imaging satellite with highest resolution and Mx of 1 metre with a high quality resolution which is a major improvement from the previous payloads in the Cartosat series.

Launch Schedule

Designation	Resolution (in meters)	COSPAR ID	NORAD ID	Power	Launch date, Time (UTC)	Launch mass	Launch vehicle	Launch site	Remarks
Cartosat-1/IRS-P5	2.5	2005-017A	28649	1100 W	5 May 2005, 04:44	1,560 kg (3,440 lb)	PSLV-G C6	SLP, SDSC	First satellite in the series.
Cartosat-	< 1	2007-	29710	900 W	10 January	680 kg (1,500 l	PSLV-	FLP, SDS	Can be steered

2/IRS-P7		001B			2007 , 03:57	b)	G C7	C	up to 45 degrees.
Cartosat-2A	Unknown	2008-021A	32783	900 W	28 April 2008, 03:54	690 kg (1,520 lb)	PSLV-CA C9	SLP, SDSC	Dedicated to be used by Indian Armed Forces.
Cartosat-2B		2010-035A	36795	930 W	12 July 2010, 03:52	694 kg (1,530 lb)	PSLV-CA C15	FLP, SDSC	Can be steered 26 degrees along as well as across.
Cartosat-2C	1.2	2016-040A	41599	986 W	22 June 2016, 03:56	727.5 kg (1,604 lb)	PSLV-XL C34	SLP, SDSC	Reduced mass and improved payloads
Cartosat-2D		2017-008A	41948	986 W	15 February 2017, 03:58	712 kg (1,570 lb)	PSLV-XL C37	FLP, SDSC	
Cartosat-2E		2017-036C	42767	986 W	23 June 2017, 03:59	712 kg (1,570 lb)	PSLV-XL C38	FLP, SDSC	
Cartosat-2F		2018-004A	43111	986 W	12 January 2018, 03:59	710 kg (1,570 lb)	PSLV-XL C40	FLP, SDSC	
Cartosat-3	0.25	2019-081A	44804	2000 W	27 November 2019, 03:58	1,625 kg (3,583 lb)	PSLV-XL C47	SLP, SDSC	Indian satellite with highest resolution in the world today, high quality imaging at 1 metre

									resolution
Cartosat-3A		TBD	TBD	TBA	~2021		PSLV		
Cartosat-3B		TBD	TBD	TBA	TBD		PSLV		

OCEANSAT

Oceansat is a series of earth observation satellites built, launched, and operated by Indian Space Research Organisation, and dedicated to oceanography and atmospheric studies. Oceansat satellites facilitate a range of applications including documenting chlorophyll concentration, phytoplankton blooms, aerosols and particulate matter as well as marine weather forecast to predict cyclones.

Oceansat-1

OceanSat-1 was the first Indian satellite built specifically for oceanographic applications. The satellite carried an Ocean Colour Monitor (OCM) and a multi-frequency scanning microwave radiometer. Oceansat-1 was launched on board a PSLV rocket on 26 May 2019.

It was capable of detecting eight spectrums ranging from 400 nm to 885 nm, all in the visible or near infrared spectrums. The second, the Multi-frequency Scanning Microwave Radiometer, collects data by measuring microwave radiation passing through the atmosphere over the ocean. This offers information including sea surface temperature, wind speed, cloud water content, and water vapour content. Although initially launched with a lifespan of 5 years, Oceansat-1 completed its mission on August 8, 2010 after serving for 11 years and 2 months.

Oceansat-2

Oceansat-2 is designed to provide service continuity for operational users of the Ocean Colour Monitor (OCM) instrument on Oceansat-1 and enhance the potential of applications in other areas. A swath width of 1420 km is provided. An along-track instrument tilt capability of ±20º is provided to avoid sun glint. Satellite was launched aboard a PSLV-CA on 23 September 2009.

SCATSAT-1

SCATSAT-1 was launched in 2016 after SCAT (Scanning scatterometer) on Oceansat-2 became dysfunctional after its life span of four-and-a-half years. SCATSAT carries a Ku-band scatterometer similar to the one on Oceansat-2.

Oceansat-3

Expected to be launched in 2020, Oceansat-3 will provide continuity to operators of OCM and enchanced ability in other applications by way of simultaneous Sea Surface Temperature (SST) measurements.

Launch schedule

Designation	COSPAR ID	NORAD ID	Power	Launch date, Time (UTC)	Launch mass	Launch vehicle	Launch site	Status	Remarks
Oceansat-1/IRS-P4	1999-029C	25758	750 W	26 May 1999, 06:22:00	1,036 kg (2,284 lb)	PSLV-G C2	FLP, SDSC	Retired	Completed a life a span more than double of planned.
Oceansat-2	2009-051A	35931		23 September 2009, 06:21	960 kg (2,120 lb)	PSLV-CA C14	SLP, SDSC	Operational	Tilt ability up to 20 degrees
SCATSAT-1	2016-059H	41790		26 September 2016, 03:42	371 kg (818 lb)	PSLV-G C35	FLP, SDSC	Operational	Continuity mission after SCAT on Oceansat-2 got dysfunctional
Oceansat-3	TBD	TBD			2020	PSLV ??	SDSC	Planned	
Oceansat-3A	TBD	TBD			TBD	PSLV ??	SDSC	Planned	