INDIAN REMOTE SENSING SATELLITES: IN ORBIT AND PLANNED SATELLITES

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ABSTRACT

The Indian Remote Sensing (IRS) Satellite system is one of the largest constellations of Remote Sensing satellites in operation in the world today. With currently 11 operational satellites in orbit to support the applications in three thematic areas like Land and Water (Resourcesat-1, Resourcesat-2, RISAT-1), Cartographic (Cartosat-1 and Cartosat-2) and Ocean & Atmosphere (Kalpana-1, INSAT- 3A, Oceansat-2, Megha-Tropiques, INSAT-3D and SARAL) – these satellites provide data in a variety of spatial, spectral and temporal resolutions. Resourecesat-1 and 2 has three specific cameras namely LISS IV Mx (5.8 m resolution and 70 km swath), LISS III (23.5m Resolution and 141 km Swath) and AWiFS (56 m Resolution and 740 km swath). When AWiFS provide 5 days repetitivity, LISS III provides 24 days repetitivity and LISS IV has the capacity to revisit in 5 days with tilting of 26^0. Cartosat-1 carries two panchromatic cameras with 2.5 m resolution with a swath of 30km. The cameras are mounted with a tilt of $+26^0$ and -5^0 along the track with respect to nadir so as to provide along track stereo images. Cartosat-2 is an advanced version of Cartosat-1 with 1m spatial resolution and a swath of 10 km. The satellite has high agility with capability of steering along and across the track up to $+45^0$. RISAT-1 is a space borne SAR in C-band at 5.35 GHz providing single/dual/quad polarisation images with 3-50 m Resolution & 10-240 km swath. Altika/SARAL mission belongs to the global altimetry system for the precise and accurate observations of ocean topography, circulation and sea surface monitoring. With these satellites and the planned thematic series of satellites in the coming years such as Cartosat-2E, Cartosat-3, Geo-Imaging Satellite (GISAT-1), Resourcesat-2A, Oceansat-3, INSAT-3DR and NISAR the Indian EO System is expected to continue to provide operational products and services enabling a variety of applications.

INTRODUCTION

The successful launch of the Indian Remote Sensing Satellite (IRS-1A) on March 17, 1988 heralded a major milestone in the establishment of operational remote sensing applications capability in the country. The IRS-1A satellite, with its LISS I and LISS II sensors enabled India to map, monitor and manage its natural resources at coarse and medium spatial resolutions. The operational availability of data products to the user organisations further strengthened the operationalisation of remote sensing applications and management in the country.

Commensurate with the ever increasing demands of the users, the technologies have been evolved both in the field of observation sensors and satellite platform. Today, India has one of the largest constellations of remote sensing satellites in operation. Currently, eleven operational satellites are in orbit – RESOURCESAT-1 and 2, CARTOSAT-1, 2, 2A, 2B, RISAT-1 and 2, OCEANSAT-2, Megha-Tropiques and SARAL. Varieties of instruments have been flown onboard these satellites to provide necessary data in a diversified spatial, spectral and temporal resolutions to cater to different user requirements in the country and for global usage. The data from these satellites are used for several applications covering agriculture, water resources, urban planning, rural development, mineral prospecting, environment, forestry, ocean resources and disaster management.

CURRENT SATELLITES IN OPERATION

Cartosat-1: Cartosat-1 was launched into a 617 km polar Sun synchronous orbit on May 5, 2005 onboard PSLV-C6. Two panchromatic cameras, PAN (Fore) and PAN (Aft) are providing high quality images with 2.5 m spatial resolution and a swath of 30 km. The cameras are mounted with a tilt of +26 degree and -5 degree along track with respect to nadir

that provides stereo pairs for the generation of Digital Elevation Model (DEM). Data from Cartosat-1 are being used for cartographic applications, DEM generation and other high-resolution geospatial applications.

Cartosat-2: This is launched on January 10, 2007 onboard PSLV-C7, carries a single panchromatic camera with the capability to provide better than 1 m spatial resolution imagery of 9.6 km swath. It was placed in a Sun synchronous polar orbit at a nominal altitude of 630 km with a re-visit of 4-5 days. The satellite can be steered along and across the track of up to ± 45 degree to facilitate frequent imaging of any specific area.

Cartosat-2A: Cartosat-2A was launched on April 28, 2008 by PSLV-C9, is an advanced remote sensing satellite with similar capabilities of Cartosat- 2.

Cartosat-2B: This was launched onboard PSLV-C15 on July 12, 2010 as a follow on mission of Cartosat-2A and is configured to provide multi-scene imaging capabilities during a pass.

Resourcesat-1: The satellite carried three cameras, namely, (i) Linear Imaging Self Scanner (LISS-4) operating in three spectral bands in the Visible and Near Infrared Region (VNIR) with 5.8 m spatial resolution, (ii) LISS-3 camera operating in three spectral bands in the VNIR Region and one in Short Wave Infrared (SWIR) band with 23.5 m spatial resolution and (iii) Advanced Wide Field Sensor (AWiFS) operating in three spectral bands in the VNIR Region and one band in SWIR with 56 m spatial resolution. The satellite has served more than 10 years, much beyond its design life and is currently providing limited imaging services. This was launched by PSLV-C5 on October 17, 2003 in a 820 km polar Sun synchronous orbit.

Oceansat-2: Cartosat-2 is a follow on mission to Oceansat-1 and was launched on September 23, 2009 onboard PSLV-C14 into a polar Sun synchronous orbit at an altitude of 720 km, with an equatorial crossing of 12:00 Hrs. Oceansat-2 carries three sensors onboard, namely, Ocean Colour Monitor (OCM), Ku-band pencil beam Scatterometer and a Radio Occultation Sounder for Atmospheric studies (ROSA). The eight bands Ocean Colour Monitor provides data at 360 m spatial resolution of 1420 km swath with two-day repetivity. The pencil beam scatterometer operates in Ku-band with a ground resolution cell of 50 km x 50 km and scans the Earth surface conically with a swath of 1400 km. It provides the wind vector in the range of 4 to 24 m/sec with better than 10% accuracy in speed and 20 degree in wind direction.

RISAT-2: RISAT-2 with X-band Synthetic Aperture Radar (SAR) was realised in association with Israel aerospace industries and launched onboard PSLV-C12 on April 20, 2009. The satellite enables imaging of the surface features during both day and night under all weather conditions. RISAT-2 has enhanced the country's capability in the disaster management support.

Resourcesat-2: It is a follow on mission to Resourcesat-1 to provide data continuity to Indian and global user community. It was launched by PSLV-C16 into a 817 km Sun synchronous orbit on April 20, 2011. As in Resourcesat-1, it has three optical remote sensing payloads, namely, LISS-3, LISS-4 and AWIFS with enhanced multispectral swath from 23 km to 70 km for LISS-4 and improved radiometric accuracy from 7 bits to 10 bits for LISS-3 and LISS-4 and 10 bits to 12 bits for AWIFS. It also carried an additional announcement of opportunities payload, known as AIS (Automatic Identification System) from COMDEV, Canada as an experimental payload for ship surveillance in Very High Frequency (VHF) band to derive position, speed and other information of ships.

Megha-Tropiques: This is a joint ISRO-CNES satellite mission for better understanding of the life cycle of convective systems and their role in the associated Energy Moisture Budget in the tropical regions. The satellite was launched by PSLV-C18 on October 12, 2011 into a 867 km orbit at an inclination of 20 degree with respect to the equatorial plane. The four scientific instruments carried by the satellite are - (i) Microwave Analysis and Detection of Rain and Atmospheric Structures (MADRAS), an imaging radiometer developed jointly by CNES and ISRO (ii) SAPHIR, a six channel humidity sounder (iii) SCARAB, a four channel scanner for radiation budget measurement and (iv) GPS-ROS, a GPS radio occultation system to provide vertical profiles of temperature and humidity of the Earth's atmosphere. All the payloads, except MADRAS, are performing satisfactorily and are providing useful scientific data for research and analysis. MADRAS sensor is not functioning now. However, the 16 months data provided by MADRAS has been calibrated and archived for scientific studies.

RISAT-1: Radar Imaging Satellite-1 (RISAT-1) is one of the mose complex satellites built and launched by ISRO in the recent past, with a versatile Synthetic Aperture Radar (SAR) payload. The satellite was successfully launched by PSLV-C19 into a Sun synchronous orbit at an altitude of 536 km on April 26, 2012. The Synthetic Aperture Radar

(SAR) Payload operating in C-band (5.35 GHz). The satellite enables imaging of the surface features during both day and night under all weather conditions. The payload operates in various modes, viz., Fine Resolution Stripmap (FRS-1), Fine Resolution Stripmap (FRS-2), Medium Resolution ScanSAR (MRS) and Coarse Resolution ScanSAR (CRS). RISAT-1 data is being extensively used for applications in agriculture, particularly paddy monitoring in kharif season and management of natural disasters like floods and cyclones.

SARAL: SARAL satellite with payloads with ARGOS and ALTIKA (SARAL), successfully launched into a Sun synchronous orbit at an altitude of 785 km, on February 25, 2013, onboard PSLV-C20. SARAL is an oceanographic satellite jointly developed by Indian Space Research Organisation (ISRO) and the French Space Agency (CNES). The Ka-band altimeter, ALTIKA, provided by CNES, operates at 35.75 Giga Hertz (GHz) for ocean applications. A dual frequency microwave radiometer (23.8 and 37 GHz) is embedded in the altimeter to correct tropospheric effects on the altimeter measurement. SARAL provides data products to the user communities for applications in marine meteorology and sea state forecasting; operational oceanography; seasonal forecasting; climate monitoring; Earth system and climate research.

NEAR FUTURE EARTH OBSERVATION SATELLITES

India's future Earth Observation Programme will ensure the continuity of the thematic series of satellites, namely, Resourcesat, Cartosat, Oceansat and Risat for land, water and ocean applications. Also, INSAT system would continue to provide support in the area of meteorology and atmosphere related studies. It is also envisaged to realise a Geo Imaging Satellite (GISAT) in geostationary orbit to enable near real time imaging. The overall aim is to maintain the continuity of services and carryout enhancements in technological capabilities with respect to sensors and payloads in order to meet the operational applications. In this regard, it is planned to design, develop and launch Cartosat-2E and Cartosat-3 in the Cartosat series of satellites, Resourcesat-2A in the Resourcesat series, Oceansat-3 in the Oceansat series, and INSAT-3DR in the INSAT series for meteorological applications, GISAT etc. A brief description of these future missions is given hereunder:

Cartosat- 2E: Cartosat-2E mission will be is a technological enhancement satellite with the mission objective of providing high resolution scene specific spot imagery. It would carry Panchromatic and Multispectral cameras operating in Time Delay Integration (TDI) mode. The spacecraft is capable of along track and across track steering up to ±45 deg and ±26 deg respectively. The spacecraft is planned to be launched by PSLV into a nominal altitude of 500 km, with a mission life of 5 years.

Cartosat-3: Cartosat-3 is a third generation cartographic imaging satellite to provide very high resolution satellite imagery. Panchromatic camera will provide 0.25m resolution data, Multispectral camera will provide 1m resolution data in four bands and Hyperspectral camera will provide 12m resolution data in 200 bands.

Resourcesat-2A: Resourcesat-2A, a follow on mission to Resourcesat-2, is intended to provide continuity of data to the users. The configuration is similar to Resourcesat-2 having three-tier imaging capability, with a unique combination of payloads consisting of three solid-state cameras, viz., a high resolution Linear Imaging Self Scanning Sensor – LISS-IV, a medium resolution Linear Imaging Self Scanning Sensor – LISS-III and an Advanced Wide Field Sensor (AWiFS).

GISAT (Geoimaging Satellite): It is an EO satellite in the Geostationary orbit of 36,000 km to provide near real time images of large areas of the country, under cloud free conditions, at frequent intervals. That is, selected sector-wise image every 5 minutes and entire image of Indian landmass every 30 minutes at 50m spatial resolution. GISAT will carry a GEO Imager with multi-spectral (visible, near infra-red and thermal), multi-resolution (50m to 1.5 km) imaging instruments.

INSAT-3DR: This is a follow-on mission to INSAT-3D to ensure data continuity for meteorological observations, and monitoring of land and ocean surfaces using Imagers and Sounders for weather forecasting and disaster warning.

Oceansat-3: It is a continuity mission to Oceansat-2 with improved and additional features. The payload consists of 13-band Ocean Color Monitor (OCM) of 360m resolution, 2 Long Wave Infra Red channels (thermal channels) for Sea Surface Temperature Measurements and a Ku-band Scatterometer. The mission will ensure continuity of ocean colour data with improvements for continuation as well as enhancing operational services like potential fishery zone and primary productivity and continuity of wind vector data for cyclone forecasting and numerical weather modelling.

MAJOR EARTH OBSERVATION APPLICATIONS

The Indian Remote Sensing programme is driven by the user needs. In fact, the first remote sensing based pilot project was carried out to identify coconut root-wilt disease in Kerala way back in 1970. These IRS satellites observe the planet Earth from space and provide synoptic and systematic information at regular intervals pertaining to land, ocean and atmosphere and several aspects of environment. This information is a key ingredient in the programmes of the Government at the Centre and State towards ensuring food and water security, sustaining our environment and eco-system, understanding weather and climate, monitoring and management of natural resources, planning and monitoring of developmental activities, support to management and mitigation during disaster events, and information for better governance.

Applications at National, State and Local levels are being carried out through well established multi-pronged implementation architecture of National Natural Resources Management System (NNRMS) in the country. User Ministries of State and Central Government departments and others institutions play a major role in utilising remote sensing technology in their own departments. In addition, Private sector, Non-Governmental Organisations and Academia also utilise this technology in different developmental sectors of the country.

A variety of applications have been carried out in different sectors like agriculture, environment, geology, water resources, land resources, urban planning, disaster management support etc. Some of the major application projects carried out in the country include Crop Acreage and Production Estimation; Groundwater Prospects Mapping; Water Resources Information System: Water Resources Assessment at Basin level; Natural Resources Census; National Land Use / Land Cover; Waste land mapping; Geomorphology & Lineament mapping; Indian Forest Cover Change Alert System (InFCCAS); Space based Information System for Decentralised Planning (SIS-DP); National Urban Information System; Snowmelt Runoff Forecasting for Himalayan River Basins; Monitoring of glacial lakes / water bodies within the Himalayan region of Indian River basins; Snow and Glacier Studies; Snow Cover Monitoring; Capacity Estimation of Reservoirs; Identification of suitable locations for the cultivation and development of Sericulture etc.

CONCLUSION

Since the launch of the first operational satellite IRS 1A, the spacecraft technology under Earth Observation Programme has been evolved in multi-faceted disciplines to meet the growing user demands for new payloads and services. Considerable progress has been achieved in several technologies as the demand for four resolutions – spatial, spectral, radiometric and temporal increase, the complexity of imaging sensors and intern the satellite systems increases. The advancements made in satellite technology in Indian Earth Observation capability have specifically addressed the requirements of various applications in the fields of land and ware management, cartography, ocean applications, urban and rural applications, disaster management, meteorology, weather and climate related studies etc.