INDIAN SPACE RESEARCH ORGANISATION

Launch of CARTOSAT-2B, ALSAT-2A, AISSAT-1, TISAT-1 and STUDSAT by PSLV-C15

Background

In its seventeenth flight (PSLV-C15), ISRO's Polar Satellite Launch Vehicle will launch five satellites – the 694 kg Indian remote sensing satellite CARTOSAT-2B, which is its main payload, and the 116 kg ALSAT-2A of Algeria, 6.5 kg NLS-6.1 AISSAT-1 of Canada, NLS-6.2 TISAT of Switzerland and STUDSAT, a picosatellite weighing less than 1 kg built by a consortium of seven Engineering colleges in Bangalore and Hyderabad – into a 630 km polar Sun Synchronous Orbit (SSO). PSLV-C15 will be launched from the first Launch Pad at Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota, in the Nellore district of Andhra Pradesh.

About PSLV

PSLV was initially designed by ISRO to place 1,000 kg class Indian Remote Sensing (IRS) satellites into 900 km polar Sun Synchronous Orbits. Since its first successful flight in October 1994, the capability of PSLV was successively enhanced from 850 kg to 1,750 kg. In its previous flight (sixteenth) on September 23, 2009, PSLV launched India's 960 kg remote sensing satellite Oceansat-2 and six nanosatellites from abroad into a 728 km polar Sun Synchronous Orbit.

The improvement in the capability of PSLV over successive flights has been achieved through several means. They include increased propellant loading in the stage motors and the strap-ons, employing composite material for the satellite mounting structure and changing the sequence of firing of the strap-on motors.

In its standard configuration, the 44.4 metre tall 295 ton PSLV has four stages using solid and liquid propulsion systems alternately. The first stage, carrying 138 ton of propellant, is one of the largest solid propellant boosters in the world. Six solid propellant strap-on motors, each carrying nine tonne of solid propellant, are strapped on to the core stage. The second stage carries 41 ton of liquid propellant. The third stage uses 7.6 tonne of solid propellant and the fourth has a twin-engine configuration with 2.5 ton of liquid propellant.

The 3.2 metre diameter bulbous payload fairing of PSLV protects the satellites carried onboard and it is discarded after the vehicle has cleared the dense atmosphere. PSLV employs a large number of auxiliary systems for stage separation, payload fairing separation and so on. It has sophisticated systems to control the vehicle and guide it through the

predetermined trajectory. The vehicle performance is monitored through telemetry and tracking.

With fifteen consecutively successful flights so far, PSLV has repeatedly proved itself as a reliable workhorse. It has demonstrated multiple satellite launch capability having launched 22 satellites for international customers besides 17 Indian satellites of which twelve were remote sensing satellites, a recoverable capsule (SRE-1), two small satellites for HAM radio communications and experimental communications, one meteorological (weather watching) satellite (KALPANA-1) and the spacecraft for India's first mission to Moon, Chandrayaan-1. PSLV has launched satellites into a variety of orbits, including polar Sun Synchronous, Low Earth, Highly Elliptical and Geosynchronous Transfer Orbits.

Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram, designed and developed PSLV. The ISRO Inertial Systems Unit (IISU) at Thiruvananthapuram developed the inertial systems for the vehicle. The Liquid Propulsion Systems Centre (LPSC), also at Thiruvananthapuram, developed the liquid propulsion stages for the second and fourth stages of PSLV as well as reaction control systems. SDSC SHAR processed the solid motors and carried out launch operations. ISRO Telemetry, Tracking and Command Network (ISTRAC) provides telemetry, tracking and command support during PSLV's flight.

PSLV-C15

PSLV-C15 employs the 'Core Alone' version of PSLV, which is almost the same as its standard configuration except for the absence of the six strap-ons (which surround the first stage of PSLV in the standard configuration and enhance its payload capability). PSLV-C15 is the sixth flight of the 'core alone' version of PSLV. One important modification in PSLV-C15 compared to the previous flight is the use of a Dual Launch Adopter (DLA) to carry two large satellites.

CARTOSAT-2B

The 694 kg CARTOSAT-2B is a state-of-the art remote sensing satellite and the seventeenth remote sensing satellite of India. Data from the satellite will find applications in cartography at cadastral level, urban and rural infrastructure development and management, as well as Land Information System (LIS) and Geographical Information System (GIS). The satellite will be placed in a 630 km high polar Sun Synchronous Orbit.

CARTOSAT-2B carries a state-of-the-art Panchromatic camera (PAN) that takes black-and-white pictures in the visible region of the electromagnetic spectrum. The imagery will have a spatial resolution of 0.8 metre. The camera covers a swath (geographical strip of land) which

is 9.6 km wide. The highly agile CARTOSAT-2B is steerable up to ± 26 degrees along as well as across the direction of its movement to facilitate imaging of any area more frequently. The satellite also carries a Solid State Recorder with a capacity of 64 Giga Bits to store the images taken by its camera. These images can later be transmitted when the satellite comes within the visibility of a ground station.

Soon after its injection into orbit and separation from PSLV-C15 fourth stage, the two solar panels of CARTOSAT-2B will be automatically deployed. The satellite's health will be continuously monitored from the Spacecraft Control Centre at Bangalore with the help of ISTRAC network of ground stations at Bangalore, Lucknow, Mauritius, Biak in Indonesia, Svalbard in Norway and Troll in Antarctica.

With ISRO Satellite Centre (ISAC), Bangalore, as the lead Centre, CARTOSAT-2B was realised with major contributions from Space Applications Centre (SAC), Ahmedabad, Liquid Propulsion Systems Centre (LPSC) at Bangalore, ISRO Inertial Systems Unit (IISU), Thiruvananthapuram and Laboratory for Electro Optic Sensors (LEOS), Bangalore. ISTRAC is responsible for initial and in-orbit operation of CARTOSAT-2B. The National Remote Sensing Centre (NRSC) receives, processes and distributes the data from IRS satellites to various users. The imagery from IRS satellites are disseminated worldwide on a commercial basis through Antrix Corporation of DOS.

Salient Features

Orbit	: Circular Polar Sun Synchronous
Orbit height	: 630 km
Orbit inclination	: 97.91 deg
Orbit period	: 97.44 min
Number of Orbits per day	: 14
Local Time of Equator Crossing	: 9.30 AM
Revisit	: 4-5 days
Lift-off Mass	: 694 kg
Attitude and Orbit Control	: 3-axis stabilised using high torque Reaction Wheels, Magnetic Torquers and Hydrazine Thrusters
Electrical Power	: 930 W Two 18 Ah Ni-Cd batteries
Payload	: PAN Camera

PAN Specifications:

Swath	: 9.6 km
Spatial Resolution	: 0.8 metre
Spectral Band	: 0.50-0.75 micron

Applications:

The multiple spot scene imagery sent by CARTOSAT-2B's PAN will be useful for village level/cadastral level resource assessment and mapping, detailed urban and infrastructure planning and development, transportation system planning, preparation of large-scale cartographic maps, preparation of micro watershed development plans and monitoring of developmental works at village/cadastral level.

Besides, CARTOSAT-2B's imagery can be used for the preparation of detailed forest type maps, tree volume estimation, village/cadastral level crop inventory, town/village settlement mapping and planning for comprehensive development, canal alignment, rural connectivity assessment, planning new rural roads and monitoring their construction, coastal landform/land use and coral/mangrove mapping and monitoring of mining activities.

Indian Remote Sensing Satellite System

India has established the National Natural Resources Management System (NNRMS) for which the Department of Space (DOS) is the nodal agency. NNRMS is an integrated resource management system aimed at optimal utilisation of the country's natural resources by a proper and systematic inventory of resource availability using remote sensing data in conjunction with conventional techniques. The major elements of NNRMS encompass conceptualisation and implementation of space segments with the necessary ground-based data reception, processing and interpretation systems and integrating the satellite-based remotely sensed data with conventional data for resource management applications.

The Indian Remote Sensing (IRS) satellites form an important element of the NNRMS for providing continuous remote sensing data services for the management of natural resources of the country. A series of IRS satellites have been launched by India starting with IRS-1A in March 1988. Nine remote sensing satellites of India are in service at present – IRS-P4 (OCEANSAT-1), TES, RESOURCESAT-1, CARTOSAT-1, CARTOSAT-2, CARTOSAT-2A, IMS-1, RISAT-2 and OCEANSAT-2 – making IRS system the largest civilian remote sensing satellite constellation in the world. CARTOSAT-2B is the latest satellite under the IRS programme.

The follow-on satellites in the IRS series include RESOURCESAT-2 carrying an improved LISS-4 as well as LISS-3 and AWiFS cameras and Radar Imaging Satellite (RISAT-1) incorporating a C-band Synthetic Aperture Radar (SAR) that has imaging capability even under cloudy conditions, both during day and night.

The data from IRS is being utilised for several applications. They include landuse/cover mapping for agro-climatic zones planning, wasteland mapping, forest cover mapping, wetland mapping, Crop Acreage and Production Estimation, Coastal Zone Regulation mapping, Identification of Potential Fishing Zones, Integrated Mission for Sustainable Development, National (Natural) Resources Information System, etc. In addition, different application studies of local/regional level are also being carried out by many organisations. With high-resolution imageries of CARTOSAT-2B, cadastral level applications will receive further impetus.

Auxiliary Payloads of PSLV-C15

Besides its main payload CARTOSAT-2B weighing 694 kg, PSLV-C15 will also carry four small satellites as auxiliary payloads. Of these, the 116 kg ALSAT-2A of Algeria is a small remote sensing satellite, whereas two Nanosats – NLS-6.1 AISSAT-1 weighing 6.5 kg and built by Space Flight Laboratory of the University of Toronto, Canada and NLS-6.2 TISAT-1 weighing one kg and built by University of Applied Sciences of Switzerland – are for testing various satellite technologies. The fourth auxiliary payload – STUDSAT – is a Picosatellite weighing less than one kg and built jointly by students from a consortium of seven engineering colleges in Bangalore and Hyderabad.

The consortium of Project STUDSAT is represented by Nitte Meenakshi Institute of Technology. The other institutions are: BMS Institute of Technology (BMSIT), Bangalore, Chaitanya Bharathi Institute of Technology (CBIT), Hyderabad, Institute of Aeronautical Engineering (IARE), Hyderabad, M S Ramaiah Institute of Technology (MSRIT), Bangalore, RV College of Engineering (RVCE), Bangalore and Vignan Institute of Technology & Science (VITS), Hyderabad. STUDSAT is the first picosatellite developed in the country.

Weighing about 650 gm, STUDSAT has the primary objective of promoting space technology in educational institutions and encourage research and development in miniaturised satellites, establishing a communication link between the satellite and the ground station, capturing the images of earth with a resolution of 90 meters and transmitting the payload and telemetry data to the earth stations.

Remote Sensing Satellites of India

Sl No	Satellite	Launch Date	Launch Vehicle	Remarks
1.	IRS-1A	Mar 17, 1988	Vostok(USSR)	Mission completed
2.	IRS-1B	Aug 29, 1991	Vostok (USSR)	Mission completed
3.	IRS-1E	Sep 20, 1993	PSLV-D1	Could not be placed in orbit
4.	IRS-P2	Oct 15, 1994	PSLV-D2	Mission completed
5.	IRS-1C	Dec 28, 1995	Molniya(Russia)	Mission Completed
6.	IRS-P3	Mar 21, 1996	PSLV-D3	Mission completed
7.	IRS-1D	Sep 29, 1997	PSLV-C1	Mission Completed
8.	OCEANSAT-1	May 26, 1999	PSLV-C2	In service
9.	TES	Oct 22, 2001	PSLV-C3	In service
10	RESOURCESAT-1	Oct 17, 2003	PSLV-C5	In service
11	CARTOSAT-1	May 5, 2005	PSLV-C6	In service
12	CARTOSAT-2	January 10, 2007	PSLV-C7	In service
13	CARTOSAT-2A	April 28, 2008	PSLV-C9	In service
14	IMS-1	April 28, 2008	PSLV-C9	In service
15	RISAT-2	April 20, 2009	PSLV-C12	In service
16	OCEANSAT-2	Sept 23, 2009	PSLV-C14	In service

Launches from India

	Vehicle	Launch Dates	Result
1.	SLV-3 E1	Aug 10, 1979	Unsuccessful
2.	SLV-3 E2	Jul 18, 1980	Successful
3.	SLV-3 D1	May 31, 1981	Successful
4.	SLV-3 D2	Apr 17, 1983	Successful
5.	ASLV-D1	Mar 24, 1987	Unsuccessful
6.	ASLV-D2	Jul 13, 1988	Unsuccessful
7.	ASLV-D3	May 20, 1992	Successful
8.	PSLV-D1	Sep 20, 1993	Unsuccessful
9.	ASLV-D4	May 4, 1994	Successful
10.	PSLV-D2	Oct 15, 1994	Successful
11.	PSLV-D3	Mar 21, 1996	Successful
12.	PSLV-C1	Sep 29, 1997	Successful
13.	PSLV-C2	May 26, 1999	Successful
14.	GSLV-D1	Apr 18, 2001	Successful
15.	PSLV-C3	Oct 22, 2001	Successful
16.	PSLV-C4	Sep 12, 2002	Successful
17.	GSLV-D2	May 8, 2003	Successful
18.	PSLV-C5	Oct 17, 2003	Successful
19.	GSLV-F01	Sep 20, 2004	Successful
20.	PSLV-C6	May 5, 2005	Successful
21.	GSLV-F02	July 10, 2006	Unsuccessful
22.	PSLV-C7	January 10, 2007	Successful
23.	PSLV-C8	April 23, 2007	Successful
24.	GSLV-F04	September 2, 2007	Successful
25.	PSLV-C10	January 21, 2008	Successful
26.	PSLV-C9	April 28, 2008	Successful
27.	PSLV-C11	October 22, 2008	Successful
28.	PSLV-C12	April 20, 2009	Successful
29.	PSLV-C14	September 23, 2009	Successful
30.	GSLV-D3	April 15, 2010	Unsuccessful