O C E A N S A T - 2

Oceansat-2 is India's second satellite built for the study of the oceans as well as the interaction of oceans and the atmosphere to facilitate climatic studies. With the goal of providing continuity of services available from Oceansat-1(IRS-P4) as well as to facilitate new applications, the 960 kg Oceansat-2 is launched into a polar Sun Synchronous Orbit (SSO) of 720 km height by India's workhorse launch vehicle PSLV during its sixteenth mission. In this mission, designated as PSLV-C14, six nano satellites are also carried by PSLV along with Oceansat-2 as auxiliary payloads to orbit. Data sent by the three payloads of Oceansat-2 – Ocean Colour Monitor (OCM), Ku-band Pencil Beam Scatterometer and Radio Occultation Sounder for Atmospheric Studies (ROSA) – are received at National Remote Sensing Centre (NRSC) of ISRO. ROSA is built by Italian Space Agency (ASI).

Oceans cover about 70% of the Earth's surface. Considering the importance of oceans as a source of food for humans as well as their important role in shaping the Earth's weather and climate, and their influence on global energy balance and biological life cycle, study of oceans becomes very important. In this context, Oceansat-2 mission acquires added significance.

Oceansat-2: The Satellite

Oceansat-2 is the sixteenth remote sensing satellite of India. The state-of-the-art Oceansat-2 weighs 960 kg at lift-off and has the shape of a cuboid with two solar panels projecting from its sides. The satellite's CFRP structure facilitates mounting of payloads while its thermal subsystem consisting of many passive materials and active gadgets helps maintain the spacecraft's temperature within safe limits. The Oceansat-2's mechanisms subsystem takes care of the deployment of its two solar panels as well as the release of OCM and Scatterometer from their 'hold down position'. It also facilitates the tilting of OCM payload to avoid sun glint. The satellite's solar panels generate electrical power during sunlit period besides charging the batteries, which supply electrical power when the satellite is in eclipse.

Ku-band Scatterometer

The Telemetry, Tracking and Command subsystem of Oceansat-2 works in S-band and its payload data is relayed through X-band. The satellite has a 64 GB solid state recorder to store the imagery for later read out. A host of Earth and Sun Sensors as well as gyroscopes provide the directional reference for its processor based Attitude and Orbit Control System to properly orient the spacecraft and provide sufficient stability during various phases of the mission, especially during imaging. Four Reaction Wheels and mono propellant Hydrazine thrusters are used as actuators to control its orientation. Thusters are also used for the satellite's orbit control.

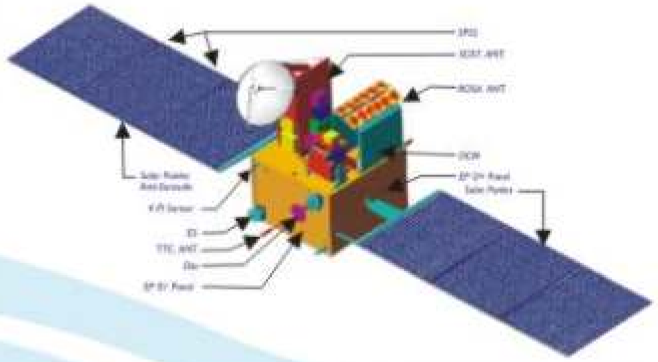
Oceansat-2 being prepared for prelaunch tests

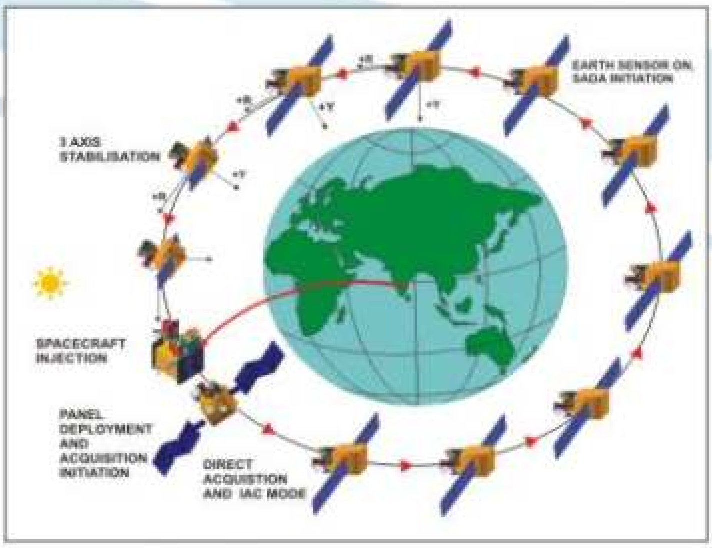
Readying Oceansat-2 for Thermo-vacuum test

The eight band Ocean Colour Monitor carried by Oceansat-2 images a swath (strip of land or ocean) of 1420 km with a resolution of 360 metre and works in the Visible and Near Infrared region of the electromagnetic spectrum. The Ku-band Scatterometer with a 1m diameter antenna rotating at 20 rpm and generating two beams, works at a frequency of 13.515 Ghz. The Scatterometer covers a swath of 1400 km and operates continuously. ROSA is a GPS Receiver for atmospheric sounding by radio occultation. It determines position, velocity and time using GPS signals. Besides providing real-time navigation data with conventional accuracy, ROSA receives RF signals from the 'rising' GPS satellites near Earth's horizon through its occultation antenna and from the excess phase delay and Doppler measurements made by this payload, vertical profiles of atmospheric parameters (density, refractivity, temperature, humidity and pressure) will be derived upto an altitude of about 30 km.

Oceansat-2 at a glance:

Structure	:	CFRP Cylinder and Aluminium Honeycomb Panels
Thermal	:	Paints, MLI blankets, Optical Solar Reflectors, Heaters and temperature controllers
Mechanisms	:	Solar Panels deployment, OCM and Scatterometer hold down release and OCM tilt
Power	:	Solar panels of 15 sq m area generating 1360 W, two 24 Ah Ni-Cd batteries
TTC	:	S-band
P/L Data transmission	:	X-band
On-board storage	:	Solid State Recorder of 64 GB capacity
Attitude and Orbit Control System	:	Earth sensors and Sun sensors, Magnetometers, Gyroscopes, mono propellant Hydrazine thrusters, Reaction wheels and Magnetic Torquers
Reaction Control System	:	100 kg of Hydrazine





Mission Profile of Oceansat-2

Orbit details of Oceansat-2:

Type	:	Near polar sun-synchronous
Altitude	:	720 km
Inclination	:	98.28 Deg
Period	:	99.31 mts.
Local time of equator crossing	:	12 noon ± 10 minutes
Repetevity cycle	:	2 days
Mission life	:	5 years

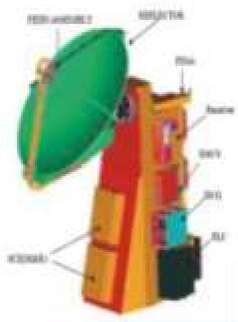
OCM at a glance:

Resolution at nadir	:	360m x 236m From 720 km
SWATH	:	1420 km
Repetitivity	:	2 Days
No. Of Bands	:	8 (Visible and Near Infrared)
Spectral bands (nm)	:	412, 443, 490, 510, 555, 620, 740, 865
Along track steering	:	±20°
Mass	:	76 kg

OCM

Scatterometer at a glance:

Altitude	:	720 km
Operating Frequency	:	13.5156 GHz (Ku-band)
Wind Vector Cell size	:	50 km X 50 km
Antenna	:	Parabola of 1.0 m dia
Scanning Rate	:	20.5 rpm
Swath (Qualified)	:	1400 km
Wind Speed Range	:	4 to 24 m/s
Wind Speed Accuracy	:	2 m/sec
Wind Direction & Accuracy	:	20 deg



Scatterometer

ROSA at a Glance:

Hardware	:	Radio Occultation Antenna, Precise Orbit Determination (POD) antenna and receiver
Frequencies of operation	:	L1 1560-1590 MHz L2 1212-1242 MHz
Horizontal resolution	:	Less than 300 kms for temperature and humidity
Vertical resolution	:	0.3 km (lower troposphere) 1-3 km (upper trophosphere)
Accuracy	:	Less than 1.0 K for temperature 10% or 0.2g/kg for humidity

ROSA

PSLV-C14: The Launcher

Positioning of nozzle end segment of PSLV-C14 first stage

ISRO's workhorse launch vehicle PSLV is chosen to launch Oceansat-2 during its PSLV-C14 mission, which is its sixteenth. During Sept 1993-April 2009 period, PSLV was launched fifteen times and scored 14 consecutive successes. In this 16 year period, PSLV has repeatedly proved its reliability and versatility by launching satellites into polar Sun Synhcronous, Gesoynchronous Transfer, Low Earth and Highly Elliptical orbits. Of the 32 satellites launched by PSLV so far, 16 have been Indian and the rest being satellites from abroad. During many of its missions, PSLV has launched multiple satellites into orbit with the maximum number being 10 during PSLV-C9 mission in April 2008.

During PSLV-C14 mission, PSLV will carry six nano satellites - Cubesat 1, 2, 3 and 4 as well as Rubin 9.1 and 9.2 - as auxiliary payloads along with Oceansat-2. The weight of these nano satellites is in 2-8 kg range. Oceansat-2 and the six auxiliary payloads are scheduled to be carried into a polar Sun Synchronous Orbit of 720 km height inclined at an angle of 98.28 deg to the equator.

The auxiliary payloads of PSLV-C14 are educational satellites from European Universities and are intended to test new technologies. After the separation of Oceansat-2 from PSLV-C14, the four cubesats will be separated, while Rubin 9.1 and 9.2 remain permanently attached to the upper stage.

Second stage of PSLV-C14 being lifted during vehicle integration

One of the nanosatellites undergoing preluanch tests

The 44.4 metre (147 ft) tall PSLV-C14 weighs 230 tons at lift-off. PSLV-C14 is the 'core alone' version of PSLV which is almost the same as PSLV 'standard configuration' except for the 'strap-on motors'. Six such 'strap-ons' surround the first stage of PSLV 'standard confirguration', but are absent in 'core alone' version. PSLV-C14 is the fifth 'core alone' mission of PSLV.

PSLV-C14 has four stages using solid and liquid propulsion systems alternately. The first stage, carrying 139 tonne of propellant, is one of the largest solid propellant boosters in the world. The second stage carries 41.5 tonne of liquid propellant. The third stage uses 7.6 tonne of solid propellant and the fourth has a twin engine configuration with 2.5 tonne of liquid propellant (compared to 2 tonne in the previous mission - PSLV-C12).

PSLV was originally designed to place 1,000 Kg class of India's remote sensing satellites into a 900 km polar Sun Synchronous Orbit (SSO). The payload capability of PSLV has been successively enhanced and in its ninth flight, PSLV-C6, in May 2005, the vehicle launched two payloads – 1,560 kg CARTOSAT-1 and 42 kg HAMSAT into a 620 km SSO. And, in its thirteenth flight, PSLV-C9, the vehicle launched ten payloads – 680 kg CARTOSAT-2A, 83 kg Indian Mini

PSLV-C14 Stages at a Glance

	STAGE-1	STAGE-2	STAGE-3	STAGE-4
Nomenclature	Core (PS1)	PS2	PS3	PS4
Propellant	Solid HTPB Based	Liquid UH25 +N_2O_4	Solid HTPB Based	Liquid MM H+MON-3
Mass (Tonne)	138.0	41.0	7.6	2.5
Max Thrust (kN)	4817	799	238	7.3x2
Burn Time (Sec)	101	147	112	497
Stage Dia (m)	2.8	2.8	2.0	2.8
Stage Length (m)	20	12.8	3.6	2.6
Control	SITVC for Pitch & Yaw, Reaction Control Thrusters for Roll	Engine Gimbal for Pitch & Yaw, Hot Gas Reaction Control Motor for Roll Control	Flex Nozzle for Pitch & Yaw, PS 4 RCS for Roll	Engine Gimbal for Pitch, Yaw & Roll, on-off RCS for Coast Phase Control

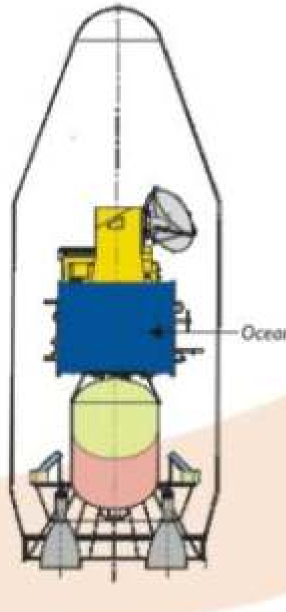
Satellite (IMS-1) and eight nano satellites from abroad. Later, the uprated version of the vehicle, PSLV-C11, launched India's first spacecraft to moon, Chandrayaan-1, into a highly elliptical orbit around the earth.

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.

The 3.2 metre diameter metallic bulbous payload fairing of PSLV-C14 protects the satellites during the atmospheric flight 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.

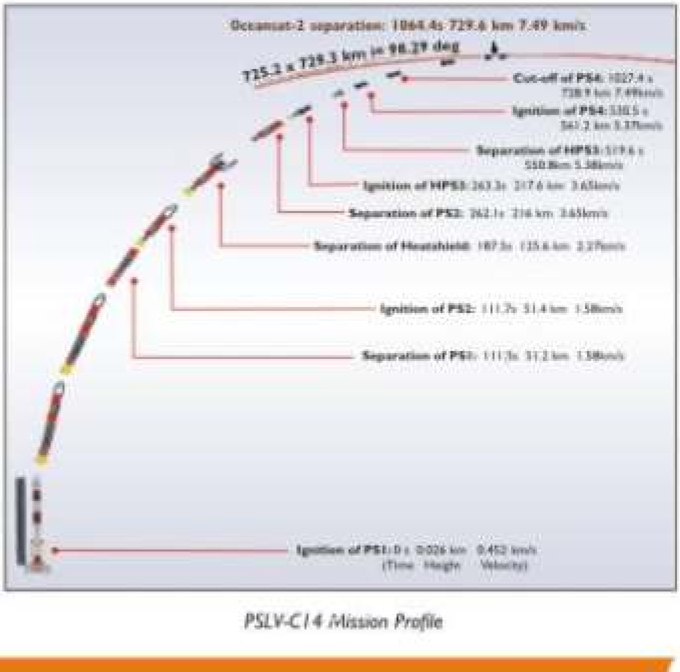
Readying the upper stages

Launch vehicle personnel working on PSLV-C14 fourth stage



Oceansat-2 in PSLV-C14 envelope

The vehicle performance is monitored through Telemetry and Tracking. With fourteen consecutively successful flights so far, PSLV has repeatedly proved itself as a reliable and versatile workhorse. It has demonstrated multiple satellite launch capability having launched sixteen satellites for international customers besides sixteen Indian payloads of which eleven were remote sensing satellites, others being a satellite for amateur radio communications, a recovery capsule (SRE-1), a meteorological (weather watching) satellite, one mooncraft and a university satellite. Though originally designed for launching payloads into polar Sun Synchronous Orbits, PSLV was used in September 2002 to launch ISRO's exclusive meteorological satellite, KALPANA-1, into a Geosynchronous Transfer Orbit (GTO) and thus proved its versatility. And in April 2007, the vehicle launched the Italian astronomical satellite AGILE into a Low Earth Orbit of 550 km height. More recently, the vehicle was also successfully used to launch a spacecraft for India's first mission to Moon, Chandrayaan-1, in 2008.



PSLV-C14 Mission Profile

Remote Sensing Data Applications

Agriculture

Water Resources

Environment

Soil

Today, imagery sent by the large constellation of Indian Remote Sensing satellites is being extensively used in various sectors of Indian economy including agriculture, rural development, water resources, urban planning, infrastructure development, marine resources, forestry, fishery, environmental monitoring and disaster management. Studies to examine the feasibility of using remote sensing data for various tasks began in the country as early as 1972 itself. Following this, analysis of imagery from Bhaskara as well as those from Landsat and SPOT satellites enabled Indian applications scientists to learn the technique of systematically interpreting them. Remote sensing satellite utilisation plan got a further fillip with the launch of IRS-1A in 1988, and during the 1990s, IRS data utilisation became institutionalised.

IRS imagery is regularly being used now for such important developmental tasks like crop acreage and production estimation, crop health monitoring, groundwater prospecting, wasteland mapping, forest cover assessment and forest fire detection, biodiversity characterisation, potential fishing zone identification, snow cover monitoring, coastal zone studies, coral and mangrove mapping, urban planning and pollution monitoring. Today, remote sensing data forms an important input in forecasting agricultural crop output. And, the success rate in digging bore wells has seen a substantial increase with the utilisation of remote sensing satellite data.

The accurate classification of wastelands, which has been done based on IRS data, leads to their reclamation and eventual utilisation for agricultural purposes. Similarly, forest cover assessment and forest fire detection are useful in managing our precious forest wealth and the associated biodiversity. This apart, pollution monitoring can help us prevent or mitigate environmental degradation. And, use of remote sensing satellite imagery can lead to orderly development of urban areas.

The launch of Indian remote sensing satellites of increased sophisitication with better spatial, spectral, temporal and radiometric resolution will enable more intense and detailed survey of India's natural resources, which is necessary for their efficient management. Today, remote sensing satellites of India provide data in the resolution range of 360 m to better than 1m. Together, they provide multispectral, hyperspectral, panchromatic as well as stereoscopic imagery. As of July 2009, India had a constellation of nine remote sensing satellites circling the Earth, mostly in polar Sun Synchronous Orbits of 550-820 km height. Imagery from some of them is being marketed worldwide.

Specifically, data from IRS-P4 (Oceansat-1) is being used for various applications both within India as well as by international users. The most significant application areas of IRS-P4 data are advisories of Potential Fishing Zones (PFZ), Coastal water pollution and sedimentation monitoring, estimation of water vapour content in the atmosphere and the prediction of the onset of Monsoon. The advisories of PFZ helped in increasing catch per unit effort. The advisories contain information about distance, direction and depth of potential fishing zones.

PFZ forecast is sent to all major fishing harbours and fishing co-operatives free of cost by Indian National Centre for Ocean Information System (INCOIS), Ministry of Earth Sciences through local newspaper, radio, fax, telephone, digital display boards, website, etc. Impact of human induced activities like urban/industrial expansion, tourism, acquaculture and pollution on the coastal waters as well as pollutants like oil slicks and contaminants can be monitored using OCM data.

Similarly, data from Scatterometer can be utilised for important activities like numerical weather prediction / forecasting, ocean state forecasting, identification of cyclone and hurricane formation and monitoring their progress. Besides, PFZ identification can be improved by the assimilation of wind information provided by scatterometer with Chlorophyll concentration data from OCM as well as Sea Surface Temperature data. This apart, Scatterometer data facilitates monitoring of changes in polar Sea Ice. And, it serves as a data source for developing algorithms for the retrieval of geophysical parameters like wind vector and ocean colour from observed data. By blending of this data with data collected from other sources, ocean and atmospheric models can be developed.

In 2008, ISRO released an Announcement of Opportunity (AO) for utilisation of both OCM and Scatterometer data for global scientific community, in response to which 28 proposals were received from International users. In addition, Oceansat-2 Utilisation Programme for Indian users has also been launched.

Disaster Warning and Management

Geoscience

Forests

Ocean Applications

Remote Sensing Satellites of India

Sl No.	Name	Weight (Kg)	Orbit (Polar Sun Synchronous- in km)	Payload	Launch Date	Launch Vehicle	Launch Centre	Remarks
1	IRS-1A	980	904	LISS-1 LISS 2A & 2B	March17 1988	Vostok	Baikonur	
2	IRS-1B	980	904	LISS-1 LISS 2A & 2B	August 29 1991	Vostok	Baikonur	
3	IRS-1E	804	820	LISS - 1	Sept 20 1993	PSLV-D1	SDSC SHAR (Shriharikota)	Could not reach orbit
4	IRS-P2	850	820	LISS-2A & 2B	Oct 15 1994	PSLV-D2	SDSC SHAR	
5	IRS-1C	1100	820	PAN, LISS-3 & WiFS	Dec 28 1995	Molniya	Baikonur	
6	IRS-P3	900	820	WiFS, MOS & X-Ray	March 21 1996	PSLV-D3	SDSC SHAR	
7	IRS-1D	1250	740x820	LISS-3, PAN & WiFS	Sept 29 1997	PSLV-C1	SDSC SHAR	In service
8	Oceansat-1 (IRS-P4)	1050	720	OCM & MSMR	May 26 1999	PSLV-C2	SDSC SHAR	In service
9	TES	1108	560	PAN	Oct 22 2001	PSLV-C3	SDSC SHAR	In service
10	Resourcesat-1 (IRS-P6)	1360	817	LISS-3, LISS-4 & WiFS	Oct 17 2003	PSLC-C5	SDSC SHAR	In service
11	Cartosat-1 (IRS-P5)	1560	630	PAN Fore & PAN Aft	May 05 2005	PSLV-C6	SDSC SHAR	In service
12	Cartosat-2	650	630	PAN	Jan 10 2007	PSLV-C7	SDSC SHAR	In service
13	Cartosat-2A	690	630	PAN	April 28 2008	PSLV-C9	SDSC SHAR	In service
14	IMS-1	83	630	Mx & HySI	April 28 2008	PSLV-C9	SDSC SHAR	In service
15	RISAT-2	300	550 (medium inclination orbit)	Radar	April 20 2009	PSLV-C12	SDSC SHAR	In service

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