अन्तरिक्ष भारत

भारतीय अन्तरिक्ष अनुसंधान संगठन

Indian Space Research Organisation

SPACE INDIA

जनवरी - जून 2016 January - June 2016

The Indian Space Programme

Space activities in the country were initiated with the setting up of Indian National Committee for Space Research (INCOSPAR) in 1962. In the same year, work on Thumba Equatorial Rocket Launching Station (TERLS), near Thiruvananthapuram, was also started. The Indian space programme was institutionalised in November 1969 with the formation of Indian Space Research Organisation (ISRO). Government of India constituted the Space Commission and established the Department of Space (DOS) in June 1972 and brought ISRO under DOS in September 1972.

Department of Space has the primary responsibility of promoting development of space science, technology and applications towards achieving self reliance and assisting in all round development of the nation. Towards this, DOS has evolved the following programmes:

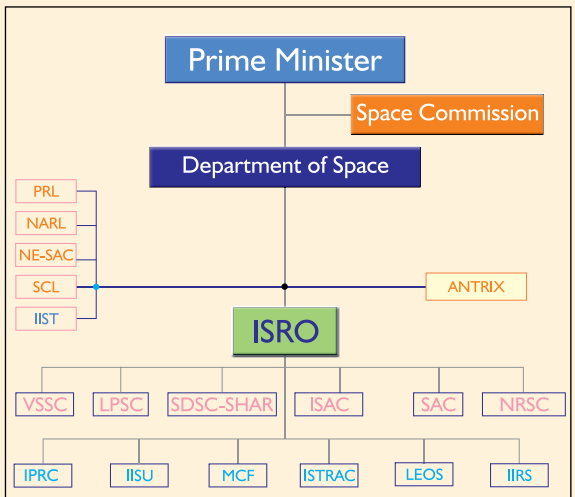
- Indian National Satellite (INSAT) programme for telecommunications, TV broadcasting, meteorology, developmental education, etc.
- Remote Sensing programme for the application of satellite imagery for various developmental purposes
- Indigenous capability for design and development of spacecraft and associated technologies for communications, resources survey and space sciences
- Design and development of launch vehicles with indigenous technology for access to space and orbiting INSAT, IRS spacecraft and space science missions
- Research and development in space sciences and technologies as well as application programme for national development

The Space Commission formulates the policies and oversees the implementation of the Indian space programme to promote the development and application of space science and technology for the socio-economic benefit of the country. DOS implements these programmes through, mainly, Indian Space Research Organisation, Physical Research Laboratory (PRL), National Atmospheric Research Laboratory (NARL), North Eastern-Space Applications Centre (NE-SAC) and Semi-Conductor Laboratory (SCL).

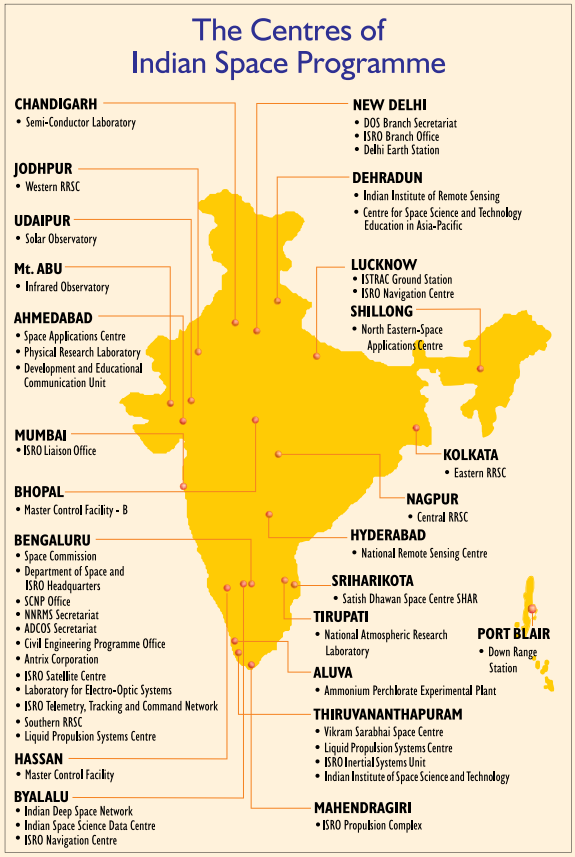
Antrix Corporation, established in 1992 as a government owned company, markets space products and services.

Both the DOS and ISRO Headquarters are located at Bengaluru. The developmental activities are carried out at the Centres and Units spread over the country.

So far, 86 Indian Satellite Missions (including six satellites built by students), two Re-entry Missions – SRE-1 and CARE module and 55 Launch Vehicle Missions (including RLV-TD) from Sriharikota have been conducted.



PRL: Physical Research Laboratory **NARL:** National Atmospheric Research Laboratory **NE-SAC:** North Eastern Space Applications Centre **SCL:** Semi-Conductor Laboratory **IIST:** Indian Institute of Space Science and Technology **ISRO:** Indian Space Research Organisation **Antrix:** Antrix Corporation Limited **VSSC:** Vikram Sarabhai Space Centre **LPSC:** Liquid Propulsion Systems Centre **IPRC:** ISRO Propulsion Complex **SDSC:** Satish Dhawan Space Centre **ISAC:** ISRO Satellite Centre **NRSC:** National Remote Sensing Centre **SAC:** Space Applications Centre **IISU:** ISRO Inertial Systems Unit **DECU:** Development and Educational Communication Unit **MCF:** Master Control Facility **ISTRAC:** ISRO Telemetry, Tracking and Command Network **LEOS:** Laboratory for Electro-optic Systems **IIRS:** Indian Institute of Remote Sensing



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Indian Space Research Organisation

जनवरी - जून 2016 January - June 2016

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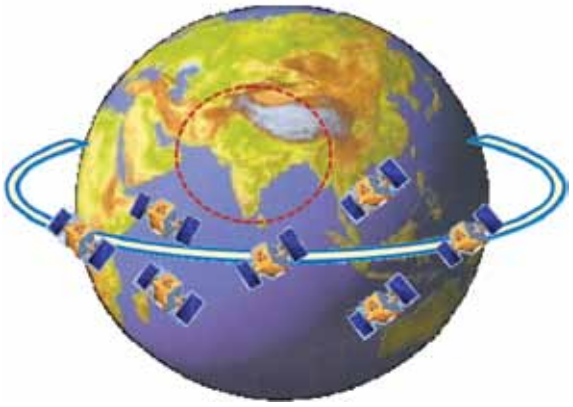
Towards Self Reliance in Navigation-IRNSS (NavIC)

Indian Regional Navigation Satellite System (IRNSS) is a regional navigation system using a combination of Geostationary Earth Orbit (GEO) and Geosynchronous Orbit (GSO) spacecraft. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 kms from its boundary, which is its primary service area. IRNSS will provide two types of services, namely, Standard Positioning Service (SPS) and Restricted Service (RS) and provides a position accuracy of better than 20 m in the primary service area.

The IRNSS system mainly consists of a Ground Segment, Space Segment and User Segment.

Space Segment

The successful launch of IRNSS-1G on April 28, 2016, the seventh and final member of IRNSS



constellation signified the completion of the IRNSS constellation. ***Honourable Prime Minister of India, Mr. Narendra Modi, dedicated IRNSS to the Nation as 'NavIC' (Navigation Indian Constellation).***

Thus, the Space Segment of IRNSS consists of seven NavIC satellites, with three in geostationary orbit and four in inclined geosynchronous orbit. The navigation payload of these satellites transmits signals in L5 and S band. The ranging payload consists of a C-band transponder, which facilitates accurate determination of the range of the satellite.

Main elements of the navigation payload are Navigation signal generator, Atomic Clock, Upconvertors, Power amplifiers, Filters and Antennas. IRNSS satellites employ the standard I-1K structure with a power handling capability of around 1660 W and a lift-off mass of around 1425 Kg and are designed for a mission life of around 10 years. All satellites in the constellation have almost identical configuration.

The three GEO satellites are placed at 32 deg E, 83 deg E and 129.5 deg E. The four GSO satellites are placed in inclined orbit with the longitude crossover of equatorial plane at 55 deg E and 111.75 deg E. GSO satellites are placed in two planes with the planes being 180 deg apart.

IRNSS-1A

The first of the seven satellites of the IRNSS Constellation, IRNSS-1A was successfully launched on-board PSLV-C22 on July 01, 2013 and placed in 55 deg E GSO.

IRNSS-1B

The satellite was launched successfully on April 04, 2014 by PSLV-C24. IRNSS-1B is functioning satisfactorily from its designated geosynchronous orbital position, at 55 deg E GSO.

IRNSS-1C

The satellite was successfully launched on-board PSLV-C26 on October 16, 2014. The satellite positioned at 83 deg E GEO is performing satisfactorily.

IRNSS-1D

The satellite was launched on-board PSLV-C27 on

Panaromic View of Fully Integrated PSLV-C31 with IRNSS-1E at Second Launch Pad

March 28, 2015 and placed at 111.75 deg E GSO. The performance of the satellite is normal.

IRNSS-1E

IRNSS-1E, the fifth satellite of IRNSS was successfully launched by PSLV-C31 on January 20, 2016. Subsequently, the satellite was positioned in the Geosynchronous Orbit at 111.75 deg East longitude with 28.1 deg inclination.

IRNSS-1E Spacecraft Integrated with PSLV-C31

IRNSS-1F

IRNSS-1F, the sixth satellite of IRNSS was successfully launched by PSLV-C32 on March 10, 2016 following which the satellite was positioned in the Geostationary Orbit at 32.5 deg East longitude.

IRNSS-1G

IRNSS-1G, the seventh satellite of IRNSS was successfully launched by PSLV-C33 on April 28, 2016. Later the satellite was placed in its Geostationary Orbital home of 129.5 deg East longitude.

Honourable Prime Minister of India, Mr. Narendra Modi, heartily thanked and congratulated all the ISRO scientists and team ISRO for completing IRNSS constellation and dedicated IRNSS to the Nation as 'NavIC' (Navigation Indian Constellation). He appreciated India's space community for making the country proud through such achievements, which have helped in improving the life of common man.

IRNSS-1G in Clean Room at SDSC SHAR

transmission of navigation parameters, etc., have been established in fifteen locations across the country. ISTRAC has established a network of stations to support IRNSS satellites consisting of ISRO Navigation Centre (INC) at Byalalu (40 km from Bengaluru), four CDMA Ranging stations at Hassan, Bhopal, Jodhpur and Shillong and twelve IRNSS Range and Integrity Monitoring Stations across the country and one IRNWT facility at Bengaluru. Additional INC and IRNWT facilities are planned at Lucknow.

User Segment

The user segment mainly consists of the IRNSS receivers capable of receiving L5 and S-band frequencies. There may be different genres of receivers, which are used by the user community depending upon the price and the purpose of their usage.

ISRO Navigation Centre (NIC) at Byalalu, the Nerve Centre of IRNSS Ground Segment

Ground Segment:

Ground Segment is responsible for the maintenance and operation of the IRNSS constellation. The Ground segment of IRNSS comprises Spacecraft Control Facility, Navigation Centre, Range and Integrity Monitoring Stations, Network Timing Facility, CDMA Ranging Stations, Laser Ranging Service and Data Communication Network. A number of ground facilities responsible for satellite ranging and monitoring, generation and

The IRNSS is an ISRO's initiative to provide independent satellite navigation services including position, velocity and time to users over the Indian region. The IRNSS will be used for - Terrestrial, Aerial and Marine Navigation, Disaster Management, Vehicle tracking and fleet management, Integration with mobile phones, Precise Timing, Mapping and Geodetic data capture, Terrestrial navigation aid for hikers and travelers, Visual and voice navigation for drivers.

PSLV-C34 Launches 20 Satellites in a Single Flight

In its thirty sixth flight (PSLV-C34), ISRO's Polar Satellite Launch Vehicle successfully launched the 727.5 kg Cartosat-2 Series Satellite along with 19 co-passenger satellites on June 22, 2016 from Satish Dhawan Space Centre SHAR, Sriharikota. This was the thirty fifth consecutively successful mission of PSLV and the fourteenth in its 'XL' configuration. The total weight of all the 20 satellites carried on-board PSLV-C34 was 1288 kg.

After PSLV-C34 lift-off at 0926 hrs (IST) from the Second Launch Pad with the ignition of the first stage, the subsequent important flight events, namely, strap-on ignitions and separations, first stage separation, second stage ignition, heat-shield separation, second stage separation, third stage ignition and separation, fourth stage ignition and cut-off, took place as planned. After a flight of 16 minutes 30 seconds, the satellites achieved a polar Sun Synchronous Orbit of 508 km inclined at an angle of 97.5 degree to the equator (very close to the intended orbit) and in the succeeding 10 minutes, all the 20 satellites successfully separated from the PSLV fourth stage in a predetermined sequence.

All the 20 Payloads are being Integrated with PSLV-C34

After separation, the two solar arrays of Cartosat-2 series satellite were deployed automatically and ISRO's Telemetry, Tracking and Command Network (ISTRAC) at Bengaluru took over the control of the satellite. Subsequently, the satellite was brought to its final operational configuration following which it began to provide remote sensing services using its panchromatic (black and white) and multi-spectral (colour) cameras.

PSLV-C34 Carrying 20 Satellites Lifts-off

The imagery sent by the Cartosat-2 series 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, precision study, change detection to bring out geographical and manmade features and various other Land Information System (LIS) and Geographical Information System (GIS) applications.

Of the 19 co-passenger satellites carried by PSLV-C34, two satellites – SATHYABAMASAT and SWAYAM were from University/Academic institutes which were built with the involvement of students from Sathyabama University, Chennai and College Of Engineering, Pune, respectively.

The remaining 17 co-passenger satellites were international customer satellites from Canada (2), Germany (1), Indonesia (1) and the United States (13).

With the successful launch of twenty satellites by PSLV-C34, the total number of satellites launched by India's workhorse launch vehicle PSLV has reached 113, of which 39 are Indian and the remaining 74 from abroad.

PSLV Upper Stage Engine (PS4) successfully restarted in space

ISRO's Polar Satellite Launch Vehicle (PSLV-C34) accomplished its thirty fifth consecutive successful flight with the launch of 20 satellites in a single mission recently on June 22, 2016. Another landmark achievement of this mission was the successful restart of its upper stage liquid engines (PS4). This has demonstrated and validated the upper stage systems for the upcoming PSLV missions to enable injection of satellites into multiple orbits.

PSLV, the workhorse of ISRO, is capable of launching satellites into different types of orbits like Sun Synchronous Polar Orbit (SSPO), Low Earth Orbit (LEO) and Geostationary Transfer Orbit (GTO), as per the customer requirements. The value engineered PSLV has flexibility in the upper stage (PS4) configuration enabling cost effective launch of different class of satellites. So far, 113 satellites have been placed by PSLV in different orbits, which include India's remote sensing and communication satellites, maiden lunar mission Chandrayaan-1, Mars Orbiter Mission (MOM) spacecraft, Indian regional navigational satellite constellation (NavIC) besides 74 foreign satellites.

Today, advancements in satellite technologies and large scale miniaturisation enable the realisation of small satellites with functionalities of earlier larger satellites. For the customers of small satellite launch service, employing a dedicated launcher is not an economic option due to larger costs. Hence, it is essential to pool multiple satellites in a single launcher to reduce the launch cost and save time. This trend poses challenges on the launcher for carrying multiple satellites into different orbits to effectively utilise vehicle payload capability. ISRO's PSLV is a unique launcher capable of meeting this type of demands with minimal vehicle changes.

In order to achieve the multiple orbits, two different options, namely having separate propulsion module or employing upper stage restart, are available. PSLV has selected the second option-restart off PS4 engine twice

with long coasting between two restarts. Even though, ISRO had enough experience in long duration satellite missions employing multiple restart of Liquid Apogee Motor (LAM) engine, a long duration launch vehicle mission was attempted during the recent PSLV-C34 mission.

PS4 stage is powered by twin liquid engines, which demands maintenance of critical parameters within the limit for overall controllability during restart. In view of these constraints and the long mission duration of around 7600 seconds between two restarts at two widely spaced points in orbit, appropriate measures were taken with overall mission planning and management, augmentation of control requirements, manoeuvring and controlling the vehicle into different orbits, reconditioning of propulsion systems and propellant management under micro-gravity conditions.

Liquid Upper Stage of PSLV

In order to build up confidence levels for the upcoming missions, experimental restart of PS4 engine was carried out for the first time in PSLV-C29 mission using available propellant, after the accomplishment of primary mission objective. Based on the success in PSLV-C29, a full complement of PS4 engine restart, the same as the functional requirement in an upcoming mission, was accomplished in the recent PSLV-C34 mission. Two engine restarts were made very close to North and South Pole validating the thermal and power management.

PSLV Upper Stage Engine

With PS4 restart, the following parameters were validated:

- Mission Planning and Overall Guidance algorithm for orbit change manoeuvres.
- Reconditioning of upper stage engine and stage systems for restart.
- Overall thermal management including fluid circuits, control components, actuators and on-board avionics systems.
- Additional powering requirements for on-board electronics.
- Ceramic servo accelerometer for better orbital parameters.

The PS4 chamber pressure during both the restarts was as predicted and closely matched with first start. Overall controllability, navigation and guidance required for manoeuvring the upper stage into two different orbits were demonstrated. Thus, PSLV-C34 mission could successfully accomplish all the requirements, which gives full confidence for executing the main mission with two functional restarts of PS4 engine.

MOSDAC completes a decade of Meteorological and Oceanographic satellite data services to the Nation

Earth Observation Systems of ISRO for Atmosphere and Ocean Monitoring have been providing continuous data since 2000. The Bopal Earth Station (BES), at Space Applications Centre, Ahmedabad was established and an operational set-up was positioned in 2006 for data acquisition, data products generation and data dissemination. This service was established through the Meteorological and Oceanographic Satellite Data Archival Centre (MOSDAC) (http://mosdac.gov.in). MOSDAC archives and disseminates data from satellites like INSAT, KALPANA-1, Oceansat, Megha-Tropiques and SARAL. MOSDAC also hosts and disseminates weather related information services and alerts over Mobile devices.

The portal provides a variety of products and services on a wide spectrum of applications comprised of weather forecasting, cyclone prediction and other vital ocean and atmospheric parameters needed by national/international forecasting agencies, research organisations, educational institutions, individual researchers and students for advanced research.

Initially, the data was used by researchers and academic institutes within the country. From a humble beginning of disseminating INSAT-3A and Kalpana data to Indian researchers, MOSDAC has marched ahead towards providing near real time satellite data to operational agencies within the country like National Centre for Medium Range Weather Forecasting (NCMRWF), India Meteorological Department (IMD), Indian Navy, Ministry of Renewable Energy, Mahalanobis National Crop Forecast Centre (MNCFC) as well as international users like NASA/NOAA, EUMETSAT and CNES. It may be noted that, ISRO is an official data partner of Committee on Earth Observation Satellites (CEOS) as well as a member of the Coordination Group for Meteorological Satellites (CGMS).

Considering the current trend and the future requirement, MOSDAC has moved towards next generation web infrastructure from website to content management system with advanced capability for visualisation of data, integration with decision support system, location based services and products disseminated as Open data.

Major Highlights of MOSDAC Services:

- A Storehouse for Space based Weather and Ocean Data
- Near real time Meteorological and Oceanographic data dissemination
- Free data to scientific and academic community
- Web and email alerts for extreme weather events
- Freely available tools and utilities for data analysis
- Advanced alerts related to cyclone and heavy rain events to civil administrators and users
- Heavy rain and cloud burst related Nowcasting over Western Himalayan region
- Weather, heat / cold wave forecasting

India's Reusable Launch Vehicle-Technology Demonstrator (RLV-TD), Successfully Flight Tested

ISRO successfully flight tested India's first winged body aerospace vehicle operating in hypersonic flight regime on May 23, 2016.

HS9 Booster Carrying RLV-TD Lifts-off from the First Launch Pad at SDSC SHAR

In this experimental mission, the HS9 solid rocket booster carrying RLV-TD lifted off from the First Launch Pad at Satish Dhawan Space Centre, Sriharikota at 07:00 hr IST. After a successful flight of 91.1second, HS9 burn out occurred, following which both HS9 and RLV-TD mounted on its top coasted to a height of about 56 km. At that height, RLV-TD separated from HS9 booster and further ascended to a height of about 65 km.

From that peak altitude of 65 km, RLV-TD began its descent followed by atmospheric re-entry at around Mach 5 (five times the speed of sound). The vehicle's Navigation, Guidance and Control system accurately steered the vehicle during this phase for safe descent. After successfully surviving high temperatures of re-entry with the help of its Thermal Protection System (TPS), RLV-TD successfully glided down to the defined landing spot over Bay of Bengal, at a distance of about 450 km from Sriharikota, thereby fulfilling its mission objectives. The vehicle was successfully tracked during its flight from ground stations at Sriharikota and a shipborne terminal. Total flight duration from launch to landing of this mission of the delta winged RLV-TD, lasted for about 770 seconds.

In this flight, critical technologies such as autonomous navigation, guidance and control, reusable thermal protection system and re-entry mission management have been successfully validated.

ISRO acknowledged the support of Indian coast guard and National Institute of Ocean Technology (NIOT) for the mid sea wind measurement and shipborne telemetry respectively in this mission.

ASTROSAT Completes 100 days in Orbit

ASTROSAT, the multi-wavelength space based observatory of India, launched on September 28, 2015, has completed more than 100 days in orbit and has experiments covering the visible, UV and X-ray wavebands to conduct observations in the area of astronomy. The Performance Verification (PV) phase of ASTROSAT was half way through in January 2016 and it was decided to review the operations conducted earlier in order to assess the gain in understanding of the spacecraft operations and the scientific outcome envisaged. Based on that review, it became certain that ISRO and the Science community stood vindicated that the outcomes would be expected and in a short while the learning from this mission would be enormous.

The ASTROSAT, with all its five payloads, is unique and the operational procedures were enhanced to suit the payload requirements unlike the earlier remote sensing or communication missions of ISRO. The astronomy payloads demand stringent geometrical constraints with respect to bright objects in space, specific state of payloads during South Atlantic Anomaly (SAA), Earth Occult and eclipse (night side) regions and finally constrained attitude manoeuvres avoiding Sun in +Roll and +yaw axes of the spacecraft simultaneously. This requires utmost careful planning on ground and executing the same on orbit.

The ASTROSAT pointing accuracy was found to be dependent upon two factors; the settling of gyro drift behaviour and lack of updates of the star sensor during the earth albedo region. Both sensors were studied on-orbit for a whole month and procedures built to counter their effects. Gyro base temperature affects gyro drift and therefore a tight control on base temperature was exacted by controlling Sun-pitch and Earth-pitch angles. This solved the gyro drift problem. Similarly, the star sensor and updates of gyro are supplemented by extensive modelling on ground. Subsequently, the procedure is incorporated into the payload programming software and automated for current operations.

As far as payloads are concerned, each of them was switched ON one at a time and the preliminary performance was checked before going further for calibrations and observations of certain target sources. Few calibrations were still pending and further observations were planned before the end of performance verification phase of this satellite in March 2016. Few highlights of the observations obtained in the first 100 days of observations with the payloads are present here:

UV Imaging Telescope (UVIT)

UVIT is the ultraviolet-visible eye of ASTROSAT. It is designed to make images over a field of ~ 28', simultaneously in three bands: Far UV (130-180 nm), Near UV (200-300 nm), and Visible (320-550 nm). The specified spatial resolution for the Ultraviolet is < 1.8" Full Width at Half Maximum (FWHM).

UVIT started observing the sky on 62nd day after the launch. Preliminary analysis of the initial observations indicate that the payload met the requirements of sensitivity

in FUV (130-180 nm) of maximum effective area as ~12 sq cm and spatial resolution of <1.8" FWHM in Ultraviolet.

Soft X-ray Telescope (SXT)

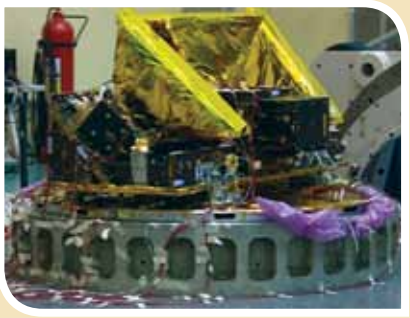
The Soft X-ray imaging Telescope (SXT) on board ASTROSAT is a grazing incidence doubly reflecting Telescope with a cooled CCD at its focus to observe cosmic X-ray sources in 0.3-8.0 keV energy band with a spectral resolution of 2.5% @ 6 keV and a spatial resolution of ~ 2 arc-mins (FWHM). The initial operations of venting of the camera body, switching ON the electronics and the temperature control and stability were achieved in October 2015.

The instrument was assessed first with the onboard calibration sources. The camera door was opened to the sky on October 26, 2015 with first light image taken was that of the Blazar PKS 2155-304. The X-ray Spectrum of Tycho Supernova remnant was taken. Tycho Supernova remnant (also called SN 1572 or 3C 10), one of the bright supernovae visible to naked eye as found in historical records. This remnant is located in the constellation Cassiopeia. The X-ray spectrum provides both the continuum spectrum which is indicative of the temperature of the plasma and the lines of the elements which are expected to be formed during the final evolution before the supernova explosion. The X-ray spectrum thus provides observational proof of these elements.

Large Area X-ray Proportional Counters (LAXPCS)

There are three Large Area X-ray Proportional Counters (LAXPCs) covering the energy range of 3-80keV. These are currently the largest area proportional counters operating in space. These counters were switched ON in October 2015, with the high voltages turned ON gradually. The gas in the counters was purified using an onboard purifier. The following figure gives the continuum spectrum of GRS 1915+105, an X-ray binary with a black hole. This source also emits jets and is termed as a micro-quasar. The continuum spectrum changes as the source goes through different spectral states.

Scanning Sky Monitor (SSM)



The aim of the Scanning Sky Monitor is to scan the sky in order to detect and locate X-ray transients in the energy range of 2-10 keV. This payload is now observing portions of half of the sky on the other side of Sun for X-ray transients. The performance verification and pipeline to put the data on the web is under progress. Stares were performed on 4U0115+63 which is a neutron star binary pulsar on October 26, 2015. During these stares, the payload could be operated with a fine time resolution.

Cadmium Zinc Telluride Imager (CZTI)

This was the first scientific payload to be switched ON during October 6-11, 2015. It operates in the 20-150 keV range and provides observations in the hard X-ray energy range. In addition to capability of extending the hard part of the energy range for studying X-ray binaries and AGNs, it has the capability to detect Gamma Ray Bursts and is also expected to reveal polarisation in bright X-ray sources in hard X-ray band. The Crab source has been used to calibrate the timing capability of the instrument. If we divide Crab observation light curve into two halves and study the change in pulse period (~33 ms), we could detect spin down of the Crab pulsar.

The individual requirements of each payload were fine-tuned and the automated operational procedure was established. ASTROSAT team got ready to meet the future challenges of the astronomy mission to explore the deep space with these world-class instruments.

Prof U R Rao selected to receive 2016 IAF Hall of Fame Award

Prof U R Rao, former Chairman, ISRO and Secretary, Department of Space, is being honoured by the International Astronautical Federation (IAF) with the 2016 'IAF Hall of Fame' Award, for his outstanding contribution to the progress of astronautics within the framework of the IAF activities.

The IAF award is intended to reward personalities for their contributions to the progress of astronautics and the Federation. In the letter to Prof Rao by the President, IAF stated that, 'It is a true honour for IAF to attribute this award to Prof Rao, who have been for many years an active participant to the success of space in general and of the Federation in particular'.

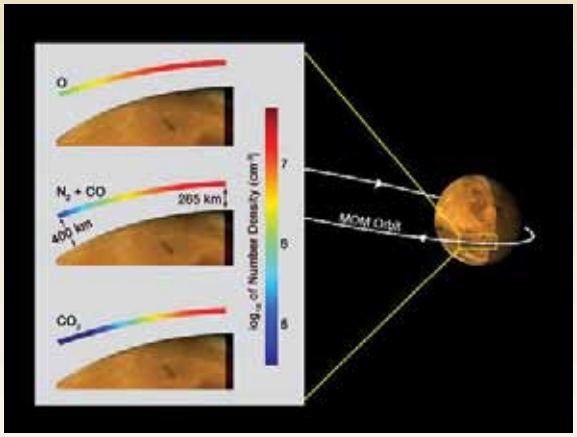
The IAF Hall of Fame consists of a permanent gallery of these personalities, including a citation, biographical information, and a picture, in a special part of the IAF web presence. This year's 67th International Astronautical Congress will be held in Guadalajara, Mexico during September 26 – 30, 2016. Prof Rao will receive the 'IAF Hall of Fame' Award and a certificate, during the closing ceremony on Friday, September 30, 2016.

MENCA observed the evening exosphere of Mars

The Mars Exospheric Neutral Composition Analyser (MENCA), onboard Indian Mars Orbiter Mission (MOM) is a mass spectrometer that provides in-situ measurements of the neutral composition of the exosphere of the Mars. MENCA is capable of measuring relative abundances of neutral constituents in the mass range 1 to 300 atomic mass unit (amu); the major gases in the Martian atmosphere fall in this range. In addition to acquiring the mass spectra in a specified mass range, the instrument has a provision to track the time variation of the abundances of a set of selectable species. The observation from MENCA will help in understanding the escape of the Martian atmosphere.

At the surface of Mars, the atmosphere is rich in Carbon Dioxide (CO_2) and very thin (~6 millibar), about 1% of that of Earth. In the upper part of the Martian atmosphere, at around 100 km, the ultraviolet (UV) rays of sunlight breaks CO_2 molecule into Carbon Monoxide (CO) molecule and Oxygen (O) atom. The CO also can be broken by solar UV radiation into C and O atoms. The oxygen atoms are about three times lighter than the CO_2 molecules and two times lighter than CO molecules. Hence, oxygen atoms have larger scale height, which means it's density at higher heights falls-off slower compared to that of CO and CO_2. Hence, there comes a region in Martian upper atmosphere where the number of O atoms exceeds the number of CO_2 molecules. The altitude at which this change-over (CO_2 dominance to O dominance) happens depends on how deep the solar UV rays penetrate the Mars atmosphere.

The figure shows the MENCA-measured abundances of the major gases, namely, atomic Oxygen (O, 16 amu), Nitrogen molecule (N_2) plus Carbon Monoxide (CO, 28 amu), and Carbon Dioxide (CO_2, 44 amu), in the exosphere of Mars on December 21, 2014, during Martian evening (around sunset in the sky of Mars), from 265 km to 400 km altitude. These



Abundances of the Major Gases Measured by MENCA

observations correspond to moderate solar activity conditions and when MOM's periapsis altitude was the lowest (~265 km).

MENCA observations have shown that the abundance of Oxygen exceeds that of Carbon Dioxide at an altitude of 270 ±10 km during Martian evening. From the variation of the abundances of different gases with the altitude, the temperature of the Martian exosphere was found to be about 271 ±5 K (-7 to +3 °C). These measurements were conducted when Mars was closer to the Sun in its elliptical orbit (i.e., at perihelion); it is still cooler when Mars is farthest from the Sun.

These are the first ***in-situ*** measurements of composition during the local dusk sector on Mars, which would help in setting up the boundary conditions for models dealing with thermal escape processes. The models are basically used to understand the evolution of atmospheres to its present state and its response to various forces.

It is important to note that the CO_2-to-O dominance transition altitude differs in day and night, and also varies with different seasons of Mars as well as depends on how active is the Sun. MENCA has provided several measurements of the composition of the key species of the Martian neutral exosphere.

ISRO participates in "Make In India Week"

Indian Space Research Organisation (ISRO) / Department Of Space (DOS) actively participated in "Make In India Week", held during February 13-18, 2016 at Mumbai. A week long exhibition was organised on this occasion showcasing ISRO's potential for supporting "Make In India" initiate. A half a day seminar on the theme "Make In India – Space" highlighting the business opportunities in the Space sector was also organised on February 17, 2016.

ISRO strives to develop various space technologies and utilise them for the rapid and all round development of the country. In this endeavour, spanning over five decades, ISRO has indigenously perfected many critical technologies essential for building satellites, launch vehicles and applications, as originally envisioned by Dr Vikram Sarabhai, the founding father of the Indian space programme. PSLV, the indigenous workhorse launch vehicle of India, has not only launched Indian satellites, but 74 satellites from 20 countries as well (by June 2016). Besides, satellites designed and developed in India are now providing many essential services to the country, and some of them are now providing services globally. All this signifies ISRO's long term adherence to 'Make in India' concept.

Seminar on "Make In India – Space"

In his opening remarks, Dr YVN Krishnamurthy, Scientific Secretary, ISRO, said that in association with ISRO, Indian private industry would be able to involve in the applications of space technology and this would facilitate bigger business opportunities for them worldwide. In his keynote address, Mr Tapan Misra, Director, ISRO's Space Applications Centre, opined that ISRO wants more private companies to make launch vehicle and satellite related components for the government run enterprise. ISRO has offered to assist them with technology transfer and in building the required infrastructure to help incubate a space industry in the country. Senior representatives from the major centres of ISRO, along with Industry partners of ISRO, including L&T, Godrej and Sure Safety Pvt Ltd. participated. A panel discussion on 'Make In India - Space: Opportunities in the Space Sector' was held and the following points were discussed:

- Scaling up from Component and Subsystem level to Entire Systems, Stages, Vehicles and Satellites
- Indigenisation of Materials and Components
- Spin-Offs of Space Technologies
- Enhancement of Applications – Communications, Broadcasting, Remote Sensing and Navigation
- Building of Launch and Satellites Integration & Test (SIT) Facility

The evolution of ISRO-Industry collaboration model from Satellite Launch Vehicle (SLV-3) onwards was highlighted and the strategic investments made by ISRO was briefed during the discussion. ISRO eagerness for enhanced role and partnership from the Indian industry towards meeting the future endeavours was stressed.

ISRO's endeavour to enhance the launch rate provides a great opportunity for industries to participate in a bigger way in space programmes. Until now, the participation of industries were limited to hardware, components or small systems and now ISRO is looking forward to fully integrated and tested systems like Control actuation systems, Liquid engines and stages, Solid motors, etc. This will enable industries to own technologies and leverage it to their advantage. Today, ISRO is planning to offer a new Small Satellite Launcher and a small Satellite to be realised by an Indian industry with ISRO's help. This will enable industries to view space as a future business area and consider investing there for capturing the future market.

An Exhibit of ISRO at "Make In India Week", Held During February 13-18, 2016 at Mumbai

As part of the Make In India program, many aspects of Earth Observation, data processing, use of Geospatial technology, location based services and Application software development in Geospatial modelling, photogrammetry and other online geo-processing related aspects were highlighted. GAGAN based smart-phone Apps was specially stressed as there is a big need for a variety of application actions. Challenges were provided to industry to make the GAGAN dongle with USB interface so that it can work on Android based mobile devices. Also, the various value additions possible on Bhuvan geo-portal platform was specially highlighted so that industry can work with NRSC, ISRO as technology innovators.

The ISRO manifest with a plan of about 12 missions per annum demands production of about 25 stages, 10 LAM engines and 200 thrusters per year by 2019-20, which shows there is tremendous potential for the Indian Industry to capitalise and contribute. Since 1980s, Industry has been a major partner in the development of many major hardware and systems for ISRO, like manufacturing of Vikas Engines and Cryogenic engines, and there has been been a steady and consistent performance by capably adopting the ISRO's stringent requirements in manufacturing processes and quality control. To facilitate the large scale production, LPSC/ISRO is embarking a new model like the "GOCO" (Government Owned and Company Operated), which will enable the Industry expertise to be utilised more effectively and in a focused manner.

Additionally, there have been various spin-offs for a large number of parts/systems developed, like Sensors (Liquid Level measurement, Temperature, Pressure, etc.) and precision control components like regulator, valve etc., many of which would find application in chemical and petro-chemical industries.

Mr Jayanth Patil of L&T, recalled how a small investment of Rs 10 crore grew up later to Rs 15,000 crore partnership with ISRO. Mr S M Vaidya of Godrej and Boyce, talked about their journey with ISRO, beginning in 1985 with the precision machining of Titanium components to fabricate Vikas engines. The experience gained with ISRO in the areas of precision fabrication, testing and quality have helped them to service orders from aerospace industry. Mr Nishith Dand of Sure Safety highlighted their partnership as an MSME and in developing a space suit. Mr Nishith also urged for an ecosystem for funding and handholding with single window system and continuity for systems developed.

The session was very interactive, and many questions were asked from user side. The questions were related to the promotion of the composite materials in ISRO activities, Robotic Research, Grid Network of Canals, Impact of Space Technology on Society, etc., which were appropriately answered by the ISRO representatives.

Antrix Corporation, which is ISRO's commercial arm, provides space products and technical consultancy services to Indian and international customers worldwide. It facilitates launches of satellites for international customers at competitive prices.

Exhibition on "Make In India – Space"

ISRO's pavilion at 'Make in India Week' intended to effectively and conspicuously appraise its mission and showcase the country's achievements in the realm of space. Several digital display systems provided information on the opportunities available for Indian industry to enter into partnership with ISRO to develop and build systems for the satellite, launch vehicle and applications domains. In addition, information on many identified technology transfer areas, including software area, where Indian industry can actively involve and develop spin-off products, was also made available.

Apart from the exhibits of scaled models and representation of various space related gadgets like Lithium-Ion Batteries, Transducers, etc., the System/Software demonstrated at ISRO pavilion were:

- Ground Penetrating Radar (GPR) that uses microwave signals for the detection of buried objects and features which are being used for snow/ice studies for the last three years at Antarctica. GPR is a low cost indigenously developed instrument and is being offered for technology transfer.
- Indian Regional Navigation Satellite System (IRNSS) is ISRO's initiative to build an independent satellite navigation system to provide precise position, velocity and time to users over the Indian region. The live demonstration of user segment of IRNSS, including the receiver, the system functioning concept and the navigation data from IRNSS was performed.
- Meteorological and Oceanographic Satellite Data Archival Centre (MOSDAC) is the store house of weather data from various Indian satellites like INSAT-3A/3D/KALPANA-1, Oceansat, Megha-Tropiques and SARAL. It also provides real time weather alerts like cloud burst, heavy rain, cyclone, heat wave etc. Samples of information available at MOSDAC in real time were demonstrated.
- Live demos of Mobile Satellite Service using GSAT-6 satellite included voice and data communication using hand held terminal, small message and position reporting service along with video conferencing using portable terminals. This system will be useful for communications during disaster and to provide communication services to remote places anywhere in India.
- GPS Aided Geo Augmented Navigation (GAGAN) is India's satellite based Augmentation System which enhances the position accuracy of GPS derived position data. ISRO efforts are now focused towards bringing GAGAN technology to mobile devices through Bluetooth/USB dongle devices. Live GAGAN navigation data was demonstrated.
- BHUVAN is a geo-platform developed by ISRO allowing a host of services towards geo-governance since 2009 and available in English, Hindi, Tamil and Telugu. Various features of BHUVAN were demonstrated.
- Integrated GIS and Image Processing (IGIS) software conceptualised by ISRO, which was designed and developed jointly by ISRO and M/s Scan Point Geomatics Ltd. (SGL), Ahmedabad. Subsequently, the technology was being transferred to M/s SGL. Various features of IGIS were demonstrated.
- FEAST is ISRO's in-house developed structural analysis software based on Finite Element Analysis. It is capable of solving linear problems like static analysis, free-vibration, stability, transients, frequency, random response, fluid-structure interaction, visco-elastic analysis, etc. The capabilities of FEAST software were demonstrated.

Serious business proposals are anticipated from the industries that include Aditya Birla Group, ABB, Excel Plants and Equipment Pvt Ltd, Esquire Capital Investment Advisors, Ministry of Science, Malaysia and Malaysian Universities for tasks like Launch Vehicle building / Launch Services, Nano Satellites, Industrial robots, Strap on Motor fabrication, building launch vehicle structure and Satellite based survey.

Geospatial Technology for Expansion of Sericulture in India

Indian sericulture is an age old practice, producing all four types of natural silk, namely, Mulberry, Tasar, Eri and Muga. Sericulture production is limited to a few pockets in our country and declining in areas under silkworm food plants is a matter of concern. The current production (about 28,708 MT during 2014-15) is not adequate to meet the demand for silk in the country. Realising the tremendous scope for improving the production and quality of silk through intervention of Geospatial tools and web technology, an ambitious project was taken up by Central Silk Board (CSB) for implementation during 2008-09 to 2013-14 period with the objective of identifying the additional potential areas for development of silkworm food plants for 108 priority districts from 24 States at 1: 50,000 scale in three phases;

Phase I: 41 districts covering all 8 States in North Eastern Region (NER).

Phase II: 45 districts covering 11 other non-traditional States namely, Bihar, Chhattisgarh, Himachal Pradesh, Jharkhand, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Uttarakhand, and Uttar Pradesh.

Phase III: 22 districts in 5 traditional States, namely, Andhra Pradesh, Jammu and Kashmir, Karnataka, Tamil Nadu and West Bengal.

It was also envisaged to develop a Geo-portal for integrating the potential area maps along with other required information for expansion of sericulture at district level. The project, unique of its kind was implemented by North Eastern Space Applications Centre (NESAC) in collaboration within State Remote Sensing Application Centres and State Directorates of Sericulture in the selected 24 States.

Methodology

Identification of potential areas for sericulture development involves evaluation of land, water resources and climatic requirements for growing silkworm food plants as well as rearing of silk worms. It needs interpretation and integration of soils, climatic parameters, vegetation and other aspects of land, like wastelands and slope using GIS. As there is limited scope of expansion of plantations under silkworm food plants, emphasis was given to identify cultivable wastelands using satellite data with standard classification approach. Six parameters of soil, namely, drainage, ground water, texture, depth and pH and two topographic parameters namely, slope and erosion, were considered for suitability evaluation.

Suitability of climate for the food plants are described in terms of: (i) temperature (ii) rainfall (water supply) and (iii) minimal length of growing period. The weather data, collected from India Meteorological Department (IMD) and the Automatic Weather Stations (AWS) established by ISRO was analysed for rainfall, maximum and minimum temperature, Potential Evapotranspiration (PET) and Length of Growing Period (LGP) for the silkworm food plants.

The most important environmental factors for rearing of silkworm are atmospheric temperature and humidity prevailing at the time of rearing. The combined effect of both temperature and humidity largely determines the satisfactory growth of the silkworms. The optimum temperature and humidity for normal growth in mulberry silkworm is between 23-28°C and 70-85% RH (relative humidity) respectively. Spatial layers on the temperature suitability for silkworm were generated as it was done in case of silkworm food plants.

Results:

a) Additional area suitable for Mulberry host plants in North Eastern States

Out of a total 108 districts, 41 districts were selected from 8 NE States covering a total geographical area of

9,35,195 sq km. Among the NE States, Nagaland is found to have maximum suitable areas- 21.9% of Total Geographical Area (TGA) that can be brought under Mulberry Sericulture. This is followed by Meghalaya (15.8%) and Sikkim (15.7%). Due to limitation of physiographic conditions and climate, Arunachal Pradesh is having very limited areas (17,242 ha in selected 7 districts) that can be brought under sericulture activities.

b) Additional area suitable for Mulberry host plants in other selected States

Among non-traditional sericulture states, Bihar has been found to have the highest percentage of areas suitable for mulberry sericulture, which is about 11% of TGA in the selected 3 districts, followed by Madhya Pradesh (10.2%) and Himachal Pradesh (9.7%). Among traditional sericulture States, Karnataka is found to have as high as 11.6% of TGA in the selected districts suitable for mulberry sericulture. The state of Punjab has been found to be least suitable for Mulberry sericulture with only 521 ha of areas delineated as marginally suitable in the selected two districts. Other two States which have been found to be less suitable for Mulberry sericulture are Uttarakhand (0.05%) and Chhattisgarh (0.6%), but Uttarakhand has about 595 ha of area under highly suitable categories in the selected 5 districts. For non-mulberry sericulture, Bihar and West Bengal have significant proportion of suitable areas for Eri, West Bengal and Uttarakhand have significant suitable areas for Muga. For tropical Tasar, Orissa has the highest percent of suitable areas (25% of TGA) in the selected 4 districts followed by Jharkhand (21.2% of TGA) in the selected districts.

Development of SILKS Geo-portal

A Geo-portal titled Sericulture Information Linkages and Knowledge System (SILKS) has been developed as a single window decision support system to provide all the sericulture related information for all the selected 108 districts. The SILKS Geo-portal developed as part of the project has been put in the public domain. SILKS is a single window, Information and Communication Technology (ICT)-based information and advisory services system for farmers, sericulture extension workers, administrators and planners working in the field of sericulture development. The portal is now made available in 12 languages namely, English, Hindi, Telugu, Kannada, Assamese, Bengali, Mizo, Manipuri, Khasi, Garo, AO-Naga and SUMI-Naga. It has 13 major non-spatial modules and 4 spatial modules, which are grouped into three categories, namely, Planning Services, Other Services and Natural Resources Management. The available modules under Planning Services are Silkworm Food Plants Production Technologies, Techniques of Rearing Silkworm, Diseases and Pest Management of Silkworm Food Plants, Improved Varieties of Silkworm Food Plants, Species of Silkworm, Processing of Cocoons, Infrastructure and Equipment and Allied Sectors and Occupations. Other Service has modules like Micro Credit and Self Help Group, Seri Marketing, Seed Distribution Centres, Weaving Reeling Centres and Schemes & Grants for Farmers. Farmers Services module consists of Weather and Weather Advisory, Disease and Pest Forewarning and Support Services.

Within a short span of about two years, the portal has been able to make significant impact particularly in NER and a number of sericulture expansion activities have been initiated based on the outcome of the study. Regular updation of information content in the portal requires continuous support from all the stakeholders based on the feedback from the users, particularly sericulture farmers.

A series of hand on trainings have been provided to officials and other stakeholders on the use of SILKS webportal. Recently SMS based sericulture advisory has been started in support of IMD, which is being linked to SILKS portal for maintaining the database and also to evaluate feedbacks. A Sericulture project atlas was released by Hon'ble Union Minister of Textiles on Nov. 17, 2015 at Central Sericultural Research and Training Institute, Mysore.

This project on Applications of Remote Sensing and GIS in Sericulture Development received National e-Governance SILVER Award 2014-15 under the category - "Innovative use of GIS Technology in e-Governance" by Department of Administrative Reforms and Public Grievances, Government of India.

IIST Secures 8th Position in all India Universities Ranking

The Indian Institute of Space Science & Technology (IIST) is ranked eighth among all Indian Universities by the National Institutional Ranking Framework, set up by the Ministry of Human Resource Development (MHRD), Government of India. The rankings were officially announced in a function held at the Vigyan Bhavan, New Delhi on April 4, 2016.

The MHRD ranking is based on a national survey that evaluated Universities on a wide set of parameters, including their excellence in teaching, quantity and quality of research output, interface with other institutions and the industry, laboratory and library resources, faculty-to-student ratio, gender equity, graduation placements, etc.

This award comes as a great recognition, a testimony to IIST's rapid growth as a pre-eminent and highly sought after educational institution, on par with many prestigious and long-established Universities of the country.

IIST at a Glance

As an autonomous institute under the Department of Space (DOS), and a deemed to be University, IIST has been offering undergraduate, post-graduate and doctoral education in the broad areas of space science and space technology. The institute currently has seven departments, with nearly hundred faculty members holding PhD. Their expertise span the various fields of aerospace engineering, avionics, earth and space sciences, mathematics, chemistry, physics and humanities.

The institute offers four years B.Tech programs in Aerospace Engineering and Avionics and a five year Dual Degree Program leading to a B.Tech degree in Engineering Physics and Post Graduate Degree in any of the following specialisations - (i) M.S. (Astronomy & Astrophysics) (ii) M.S. (Earth System Science) (iii) M.S. (Solid State Physics) and (iv) M.Tech (Optical Engineering). The selection of students for the undergraduate programs is done through the highly competitive Nation-wide Joint Entrance Examinations JEE-Main and JEE-Advanced), which ensured the admission of students with the best academic credentials. All meritorious students are supported financially through DOS scholarships for the duration of their study.

Since its founding, five batches of undergraduate students have graduated from IIST, who were subsequently placed in the various ISRO/DOS centers. The institute has been thus fulfilling one of its important mandates of providing quality human resource for Indian Space Research Organisation (ISRO).

The institute also offers post-graduate programs in 14 emerging and highly sought after specialisations. These two years post-graduate programs are all research oriented, with one full year dedicated to supervised research work.

The institute recognises the relevance of research and encourages all its faculty members to guide and supervise young scholars for the PhD program as well as for Post-Doctoral program. Currently, nearly 100 doctoral students are working closely with faculty members on various problems. These research-intensive doctoral programs are structured to help students to evolve into independent researchers and teachers who can contribute to the broadening of knowledge in their fields.

Since 2012, thirteen doctoral degrees have been awarded by the institute, with over 300 research

publications appearing in science and engineering journals of global standing. Within a short span of 8 years, the institute has also put together 52 well equipped laboratories catering to its various research and teaching needs.

The DOS/ISRO has established an endowed fellowship at the Graduate Aerospace Laboratories of the California Institute of Technology (GALCIT), California, USA in the honor of Dr. Satish Dhawan, the former Chairman of ISRO. The fellowship provides an excellent opportunity to the top ranking graduating student from Aerospace Department of IIST, to pursue Masters in Space Engineering at California Institute of Technology (Caltech). On completion of the course and award of degree by Caltech, the student will pursue a career in Space at ISRO. Since last year, the JPL/NASA has been accepting three B.Tech students of IIST for a 2-month internship program at the JPL. In the past, IIST students have also undergone internship programs at the Lunar and Planetary Institute (LPI), Houston and also at the University of Texas, Arlington.

The institute is committed to excellence in teaching, learning and research. IIST fosters state-of-the-art research and development in space studies and provides a think-tank to explore new directions for the Indian space programme.

The IIST campus is located at Valiamala, about 25 kms from Thiruvananthapuram city.

A View of IIST Student Hostels at the Valiamala Campus

ISRO receives NIQR-GKD Award for Outstanding Organisation

ISRO received the Award for Outstanding Organisation-2016 from National Institution for Quality and Reliability (NIQR) during 15th NIQR National Convention held at Chennai. As part of quality promotion activity, NIQR recognises Organisations for their outstanding contribution to the practice of Total Quality in all their activities and gives away awards during its Annual Convention.

ISRO was selected for its significant achievements and over all management, which would not have been possible, but for practice of total quality in

their design, procurement, assembly and execution. The award was given in recognition of ISRO's major accomplishments like Mars Orbiter Mission, Launch Vehicle Services like PSLV, GSLV, launch of various earth observation and communication satellites, deployment of India's own Regional Navigation Satellite System (IRNSS), etc

About NIQR

National Institution for Quality and Reliability (NIQR), a world class professional Institution dedicated for promotion of Excellence in Quality with its Head Quarters at Chennai, came into existence in 1987. The Institution has been playing a vital role in promoting Quality as a way of life in Indian Industry and Services organisations, organising high quality programmes through workshops, seminars, conferences, consultancy services, publication of study materials and rewarding eminent people and organisations who have excelled with their outstanding performance in the practice of quality tools and techniques. NIQR is also playing a key role in National Quality Movement.

About the Convention

NIQR organises the National Convention once in two years, with themes that reflect contemporary needs and aspirations of the Country. The 15th NIQR National Convention was co-organised by Quality Council of India (QCI) held during June 10-11, 2016, with a theme "Skill India for Sustainable Global Quality".

The award consists of a citation and a plaque.

World's Space Agencies Unite To Face The Climate Challenge

For the first time, under the impetus of the Indian Space Research Organisation (ISRO) and the French Space Agency (CNES), space agencies of more than 60 countries agreed to engage their satellites, to coordinate their methods and their data to monitor human-induced greenhouse gas emissions.

The COP21 climate conference held in Paris during December 2015 acted as a wake-up call in this context. Without satellites, the reality of global warming would not have been recognised and the subsequent historic agreement at the United Nations headquarters in New York on April 22, 2016 would not have been signed. Out of the 50 essential climate variables being monitored today, 26 - including rising sea level, sea ice extent and greenhouse gas concentrations in all the layers of the atmosphere - can be measured only from space.

Heads of the World's Space Agencies at New Delhi

The key to effectively implementing the Paris Agreement lies in the ability to verify that nations are fulfilling their commitments to curb greenhouse gas emissions. Only satellites can do that. Invited to New Delhi by ISRO and CNES on April 3, 2016, the world's space agencies decided to establish "an independent, international system" to centralise data from their Earth-observing satellites through the 'New Delhi Declaration' that officially came into effect on May 16, 2016.

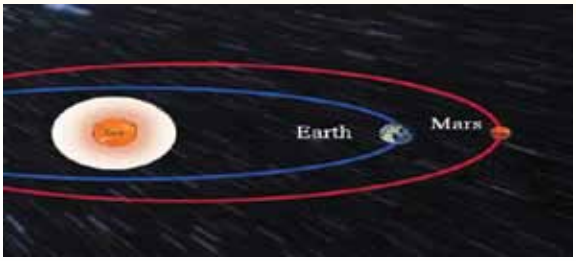
The goal now will be to inter calibrate these satellite data so that they can be combined and compared over time. In other words, it is to make the transition to closely coordinated and easily accessible 'big space data'.

"It is overwhelming to see the unilateral support of all space agencies to use space inputs for monitoring climate change" said ISRO Chairman A.S. Kiran Kumar. "Earth observation satellites provide a vital means of obtaining measurements of the climate system from a global perspective. ISRO is committed for the continuity of earth observation data, through the thematic series of satellites, with improvements en-route, to meet contemporary as well as future needs. ISRO is also engaging with CNES, JAXA and NASA for realising joint missions for global climate observation with advanced instruments."

"This is a historic event that reaches far beyond the space sector and is a perfect example of the kind of success that can only be achieved through international cooperation" said CNES President Jean-Yves Le Gall. "With this consensus among space agencies from more than 60 nations, including the world's leading space powers, the international space community and scientists now have the tools they need to put their talent, intelligence and optimism to work for the good of humankind and our planet."

MOM successfully comes out of 'whiteout' Phase

Mars Orbiter Mission (MOM) spacecraft experienced the 'whiteout' geometry during May 18 to May 30, 2016. The planets continuously in motion can align with the sun causing 'whiteout' or 'blackout' causing communication disruptions. In this particular geometry, the Earth came in between the Sun and Mars causing a 'whiteout'.

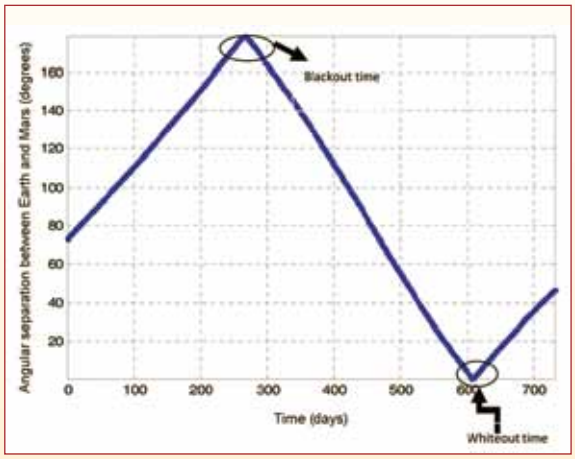


A 'whiteout' occurs when the Earth is between the Sun and Mars and too much solar radiation may make it impossible to communicate with the Earth. The maximum duration of 'whiteout' is around 14 days. MOM spacecraft experienced the 'whiteout' during May, 2016. However, MOM is built with full autonomy to take care of itself for long periods without any ground intervention.

The entire planning and commanding for the 'whiteout' was completed 10 days before the actual event. No commanding was carried out on the spacecraft in the 'whiteout' period and Payload operations were suspended. Fault Detection, Isolation and Recovery features were kept enabled, so as to take care of any contingency on the spacecraft. Master Recovery Sequencer was programmed, to acquire the attitude of the spacecraft and ensure communication with earth even in case of attitude loss.

The spacecraft came out of 'whiteout' geometry successfully on May 30, 2016 and has been normalised for regular operations.

It may be recalled that MOM went through a communication 'blackout' as a result of solar conjunction from June 02, 2015 to July 02, 2015. Telemetry data was received during most of the conjunction period except for 9 days from June 10-18, during superior conjunction. MOM was commanded with autonomy features starting from May 18, 2015, which enabled it to survive the communication 'blackout' period without any ground commands or intervention. The spacecraft emerged out of 'blackout' period with auto control of the spacecraft systems successfully. This experience had enabled the mission team to program a spacecraft about one month in advance for all operations.



Angular Separation between Earth and Mars at Sun Centre

Mosaic of Martian North Pole and Ice Cap from MOM Prepared

Mars Colour Camera (MCC) on-board Mars Orbiter Mission (MOM) captured many images of North Pole of Mars. Topographically corrected MCC reflectance mosaic is prepared by Space Applications Centre (SAC), ISRO, Ahmedabad using nine MCC images observed during December 16, 2015 to January 26, 2016.

Mars Colour Camera (MCC)

The period of observation corresponds to the solar longitude (***Ls***) from 82° to 100° of 33rd Martian year. To keep track of time on Mars, the position of Mars in its orbit around the Sun is used; it is a kind of longitudinal system that goes from 0 to 360 degrees. Therefore, solar longitudes (***Ls***) is used to keep track of the seasons on Mars; the ***Ls***=0° is the start of northern spring and ***Ls***=180° is the start of southern spring.

The individual images are converted to atmosphere reflectance (***I/F***) and then, Minnaert topographic correction is applied. The image shown is projected into Sample Azimuthal Equal Area and the resulting pieces were mosaicked for full view of the polar cap.

The seasonal Martian polar caps wax and wane in response to the condensation and sublimation of carbon dioxide (CO_2) resulting from seasonal insolation changes on Mars.

In northern winters (***Ls***=270-360°), the polar cap grows much larger in area since atmospheric CO_2 freezes and deposits a layer of dry ice (frozen CO_2) on top of the ice cap and the surrounding terrain. When summer returns (***Ls***=90-180°), warm temperatures cause the dry ice to sublimate away, and the polar cap shrinks in size.

The period of North Pole observation from MCC belongs to the end of northern spring and early summers, showing seasonal sublimation. The northern ice cap on Mars extends about 1,100 km from pole. Major topographic and surface albedo features are easily seen in this mosaic ***(provided in the back cover of this Issue)***. The edge of the ice cap is surrounded by "polar layered terrain", a series of layers of ice and dust. The ground throughout the Polar Regions appears to have lots of ice in or under the soil. Winds caused by temperature differences between the ice cap and its surrounding, blow throughout the Polar Regions. They carve interesting grooves into the ice cap, and build up sand dunes in areas around the pole. Light brown areas are a mix of ice and dust and are called "polar layered terrain". Dark brown areas around the ice cap are sand dunes. The huge canyon, Chasma Boreale is seen in the ice cap on the left side of the picture.

Geospatial Technology for Swachh Bharat Abhiyaan

A novel initiative to contribute to the Swachh Bharat Abhiyaan using the Geo-spatial Technology (GST) was taken up jointly by the central Government institutions in Dehradun. This programme was coordinated by Indian Institute of Remote Sensing (IIRS), a unit of ISRO, and supported by the local authorities, Nagar Nigam, Dehradun.

Geospatial Technology (GST)

Geospatial Technology (GST) includes a suite of three technologies: 1) Global Navigation Satellite System (GNSS), or more popularly, Global Positioning System (GPS) which provides geographic location or positions of specific points on the Earth 2) Space-borne satellite images which provide pictorial description of the point in the context of neighborhood locations 3) Geographical Information System (GIS) which integrates these two along with many other information layers like road and infrastructure, topography, land use, soil, geology, etc., and also allows people to generate and use maps required to manage our resources for the benefit of common man. With the availability of GPS data through smart phones at affordable cost, better governance and providing location based services to the public has become feasible. Application of GST in Swachh Bharat Abhiyaan has been attempted for the first time by IIRS, Dehradun.

Methodology

The reconnaissance survey using India's GPS-Aided Geo-Augmented Navigation (GAGAN) receiver was carried out to precisely locate the authorised and unauthorised garbage dumping sites covering five main routes in Dehradun city. The road network connected to the dumping sites was also mapped for route planning. Geo-tagging of all the participating government institutes were also done. GIS techniques such as geo-fencing (buffering), geospatial analysis (spatial and attribute queries), etc., were used to develop an optimum implementation plan. A map was prepared representing geo-fencing of each institute considering time constraints and resource allocation. Each route was supported with respective teams of both IIRS and collaborative institutes (471 volunteers and 43 Nagar Nigam personnel) to implement the proposed activity. Real-time monitoring and support was provided to the overall activity from IIRS control room.

Twenty two garbage dumping sites and roadsides were cleaned within a span of 3 hours. Around 45 m^3 (approximately 10 ton) of garbage was collected and disposed during this entire exercise. The details of this event are available at www.iirs.gov.in/SBA.html.

Mapping and monitoring of Garbage sites through Crowd sourcing

One of the unique results of this novel multi-institutional initiative is the conceptualisation of crowd sourcing tool to identify, map and monitor the dumping sites. A Swachh Bharat Mobile Application (beta version) is being developed by IIRS in collaboration with Indian Institute of Technology (BHU), Varanasi which allows any user to install the mobile app in their smart phones and send the garbage site geo-tagged information to the Nagar Nigam server (if available) for further action. Thus, crowd sourcing for Swachh Bharat will be soon realised and implemented with the help of Academic Institutions as a regular exercise for the cleanliness of the city.

Polarimetric DWR at Cherrapunjee dedicated to the Nation

Shri Narendra Modi, Hon'ble Prime Minister of India, dedicated the first Indigenously developed Polarimetric Doppler Weather Radar (DWR) installed at Cherrapunjee, to the Nation on May 27, 2016 remotely from Polo ground in Shillong, Meghalaya. The DWR has been designed and developed by Radar Development Area, ISRO Telemetry Tracking and Command Network (ISTRAC), ISRO and manufactured by Bharat Electronics Limited (BEL), Bengaluru. The DWR was realised with active support from Regional Meteorological Centre (RMC), Guwahati of India Meteorological Department (IMD) and North Eastern Space Applications Centre (NESAC), Department of Space, Umiam, Shillong.

Hon'ble Prime Minister while dedicating the DWR to nation said ***"We all know Cherrapunjee, for being the place that receives the highest rainfall in the World. Today, another feather has been added to its cap. The Doppler Weather Radar at Cherrapunjee has been dedicated to the Nation. I congratulate the Indian Space Research Organisation, Bharat Electronics Ltd. and the Indian Meteorological Department for setting up this Radar in Cherrapunjee.***

The North East, a land of beauty and adventure, has been hit by several natural calamities in the recent past, on account of heavy rain and landslides. This Weather Radar System will enable better weather forecasts, especially for the North Eastern region. This should help in minimising the threat posed by extreme weather conditions."

The Doppler Weather Radar (DWR) provides advance information, enhancing the lead-time so essential for saving lives and property, in the event of natural disasters associated with severe weather. Though the conventional radars are able to track and predict cyclones, the DWR provides detailed information on storm's internal wind flow and structure. The severity of the weather systems can thus be quantitatively estimated more accurately than ever before and more precise advance warnings can be generated for saving human lives and property. The polarimetric capability of the Radar will significantly improve the accuracy of rainfall estimation leading to accurate and timely flash flood warnings.

The DWR System at Cherrapunjee

The DWR, being the first S-band (operating at 2.7 - 2.9 GHz) dual polarimetric Doppler Weather Radar, can detect weather phenomena upto 500 km. This system installed at a place that receives the highest rainfall on Planet Earth, shall open up tremendous research opportunities in the areas of monsoon dynamics, Cloud Physics, impact of orography in precipitation process, precipitation characterisation, thunderstorm and hailstorm genesis and evolution, etc. The data from the DWR is also expected to support a host of operational programmers of IMD and NESAC/ISRO. The near real time precipitation estimates from the DWR shall improve the Flood Early Warning System (FLEWS), being developed by NESAC for NE states. It will also enable IMD and NESAC to take up operational activities on thunderstorm now-casting and hail now-casting for NE states.

Temporal repetitive mapping of waterbodies across India

National Remote Sensing Centre (NRSC), ISRO at Hyderbad monitors the status of all the water bodies in the country using satellite images and provides water spread area information on a fortnightly basis. Images from Indian remote sensing satellites, Resourcesat-2 and RISAT-1 are regularly processed using automated spectral and hierarchical analysis algorithm and to generate spatial water information.

This consists of all surface water features like reservoirs, tanks, lakes, ponds, rivers and streams. Due to presence of cloud cover, the daily processed data are time-composited and fortnightly water spread information is made available through Bhuvan Geo-spatial Platform. ***(To access, visit Bhuvan Thematic Services and select "Water Bodies" under "Select Theme" option)***.

Snapshot of Water Bodies Fraction Information

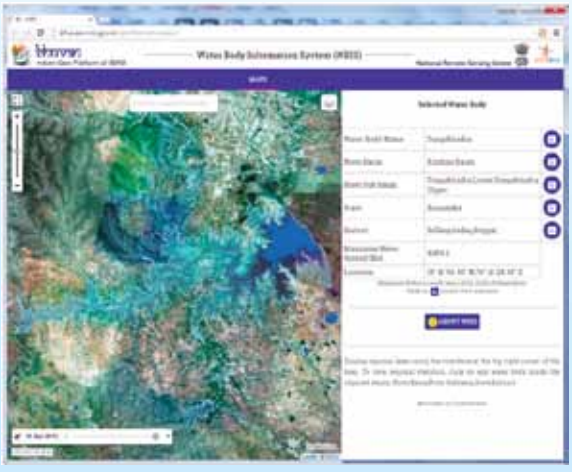
This water spread layer is used to generate grid-wise (grid size of 5 km x 5 km) water body fraction product for download through Bhuvan Open Data Archive (select ***"Programmes/Project" under Category, "National Information System for Climate and Environment Studies (NICES)" under Projects, "Terrestrial Science" under Group and "AWiFS: Water Bodies Fraction" under Product)***. This data is useful in hydrological modelling, drought assessment, surface water dynamics analysis, etc.

The temporal water spread information generated since 2012 is organised in a geo-spatial database in the form of water bodies. This data is published on Bhuvan Geo-Platform under Water Body Information System (WBIS) for visualisation and spatial query. It provides integrated view of water-spread dynamics for more than 12,500 water bodies in the country. The geo-spatial tool provides:

- Fortnightly water spread area
- Graphical representation of multi-temporal water spread (since 2012)
- Monthly scenarios for each water body

It also provides regional water spread scenarios at river basin, river sub basin, district, and state level.

It may be noted that due to the presence of cloud, there could be underestimation of the spread in few areas, as optical images cannot penetrate cloud cover. Glacial lakes and water bodies in hilly regions of Himalayas are not part of this database.



Snapshot showing Recent Water Spread of Tungabhadra Reservoir

Postal Stamps featuring SARAL and Megha-Tropiques Satellites Released

India and France jointly released a set of two commemorative postage stamps, highlighting 50 years of space co-operation between the two countries. Department of Posts, India and La Poste, France released joint Stamps to commemorate 50 years of co-operation in space between India and France. The stamps were jointly released by Prime Minister of India and President of France.

The Prime Minister of India and President of France Jointly Releasing the Stamps

The stamps contain the images of "Satellite with ARgos and ALtika" (SARAL) and Megha-Tropiques satellite. The two satellites were developed jointly by Indian Space Research Organisation (ISRO) and the Centre National d'Etudes Spatiales (CNES) of France.

The satellites Megha-Tropiques and SARAL were launched by the Indian PSLV-C18 in 2011 and PSLV-C20 in 2013 respectively. The data provided by these satellites is being utilised by ISRO and CNES and is being shared with other countries. The partnership between India and France in space started in 1964 when the two countries entered into a protocol agreement for cooperation in space research. The countries have since continued to work together for the advancement of the peaceful uses of outer space.

The honorable Prime Minister also visited the CNES Space Centre, Toulouse on the following day (11/04/15) of the release of stamps.

Commemorative Indian Postage Stamps

Stamp on India-France Joint Issue
Date of Issue: 10th April, 2015
Denomination: INR 5.00

Stamp on India-France Joint Issue
Date of Issue: 10th April, 2015
Denomination: INR 25.00

Stamp on Dr. A.P.J. Abdul Kalam
Date of Issue: 15th October 2015
Denomination: INR 5.00

Stamp on India in Space: OCEANSAT-I
Date of Issue: 29th Sep 2000
Denomination: INR 3.00

Stamp on India in Space: INSAT 3B IN ORBIT
Date of Issue: 29th Sep 2000
Denomination: INR 3.00

Stamp on India in Space (SE-TENANT)
Date of Issue: 29th Sep 2000
Denomination: INR 3.00

Stamp on Indian Remote Sensing Satellite-1A
Date of Issue: 18th Mar 1991
Denomination: INR 6.50

Stamp on Indo-Soviet Joint Manned Space Flight
Date of Issue: 03rd Apr 1984
Denomination: INR 3.00

Stamp on World Communications Year
Date of Issue: 18th Jul 1983
Denomination: INR 1.00

Stamp on APPLE Satellite
Date of Issue: 19th Jun 1982
Denomination: INR 2.00

Stamp on SLV-3 - ROHINI
Date of Issue: 18th Jul 1981
Denomination: INR 1.00

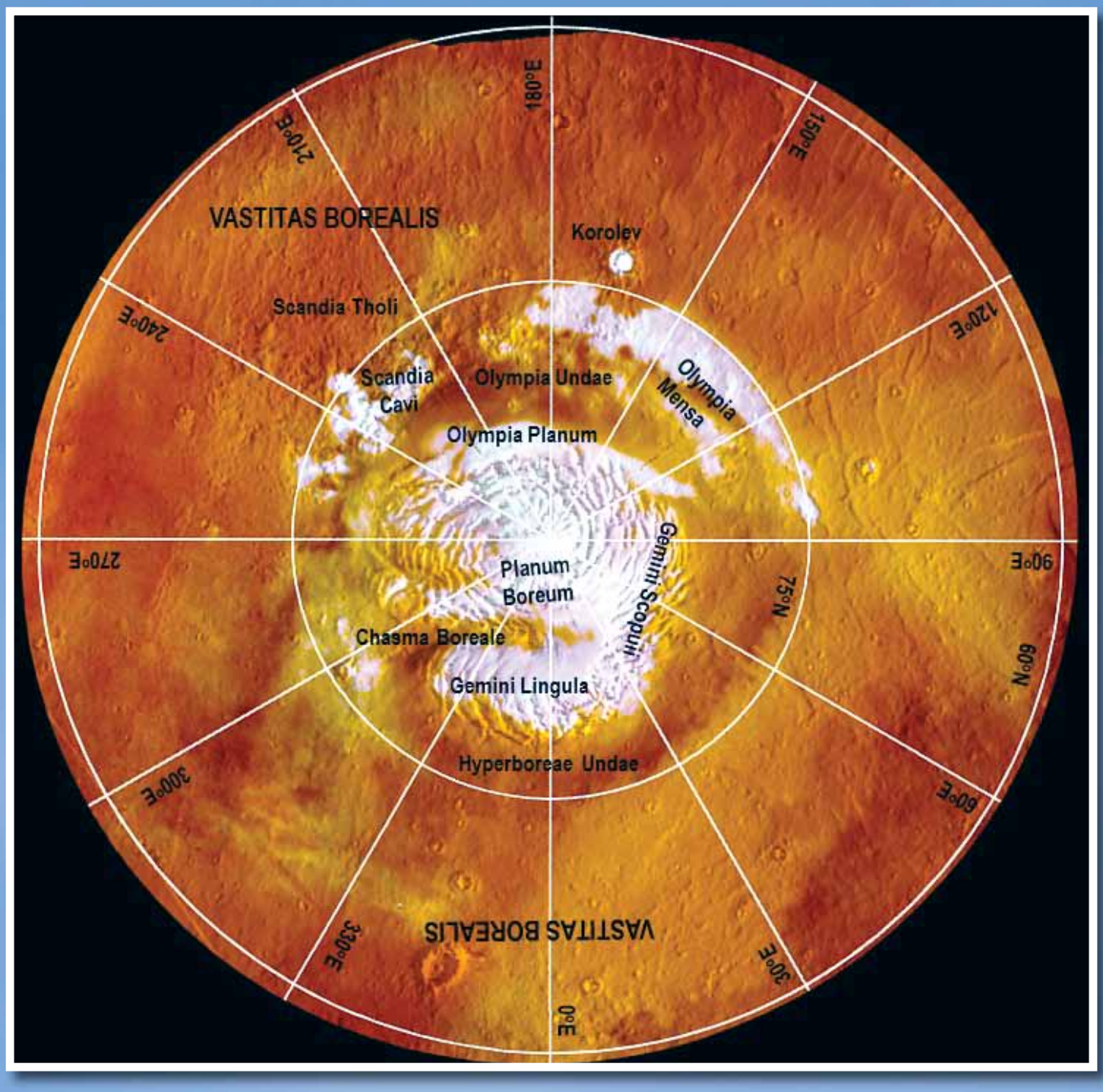
Stamp on Satellite Instructional Television Experiment
Date of Issue: 01st Aug 1975
Denomination: 25 nP

Stamp on ARYABHATA
Date of Issue: 20th Apr 1975
Denomination: 25 nP

Stamp on VIKRAM A SARABHAI 1919-1971
Date of Issue: 30th Dec 1972
Denomination: 20 nP

Stamp on ARVI Satellite Earth Station
Date of Issue: 26th Feb 1972
Denomination: 20 nP

Stamps from other countries on Indian Space Programme



MCC Mosaic of the Martian North Polar Region, Azimuthal Equal Area Projected from 60°N to 90°N, During Ls=82-100° (Martian Year 33). Major Topographic and Surface Albedo Features are Labeled.

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