अन्तरिक्ष भारत
SPACE INDIA

भारतीय अन्तरिक्ष अनुसंधान संगठन

Indian Space Research Organisation

जुलाई-दिसम्बर 2016 July-December 2016

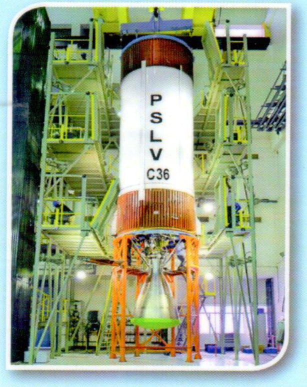
PSLV-C35 Lift-Off

SCATSAT-1

GSAT-18

GSLV-F05 Cryogenic Upper Stage

INSAT-3DR Integrated with GSLV-F05



PSLV-C36 Second Stage

Resourcesat-2A

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.

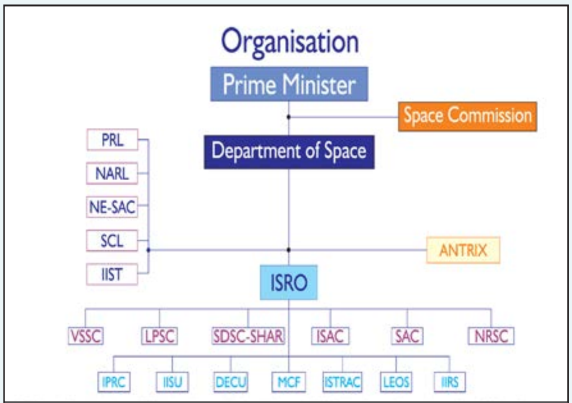
Department of Space has the primary responsibility of promoting the development of space science, technology and applications towards achieving self reliance and assisting in all round development of the nation. Towards this, DOS has evolved the following programmes:

- 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, navigation 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, 92 Indian Satellite Missions (including eight satellites built by students), two Re-entry Missions – SRE-1 and CARE module and 59 Launch Vehicle Missions (including RLV-TD and Scramjet Engine - TD) have been conducted from Sriharikota.



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 **SAC:** Space Applications Centre **NRSC:** National Remote Sensing 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-optics Systems **IIRS:** Indian Institute of Remote Sensing

अन्तरिक्ष भारत
SPACE INDIA
भारतीय अन्तरिक्ष अनुसंधान संगठन
Indian Space Research Organisation
जुलाई-दिसम्बर 2016 July-December 2016

Contents

Editors

Deviprasad Karnik
A S Padmavathy
B R Guruprasad

Editorial / Circulation Office
Publications & Public Relations Unit, ISRO Headquarters, Antariksh Bhavan, New BEL Road, Bengaluru - 560 231, India.www.isro.gov.in
Designed by Solus Communication Resources and Printed at Print-O-Graph, Bengaluru.

Geo-tagging of MGNREGA Assets by ISRO

Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) enacted in 2005, aims to enhance livelihood security of rural people by guaranteeing 100 days of wages in a financial year for adults willing to take up unskilled manual work. This initiative is unique of its kind across the globe in poverty alleviation. Around 30 lakh (3 million) assets are created annually across the country under the rural job scheme, which involves water harvesting, drought relief and flood control as preferred activities. Convergence with other schemes necessitates further transparency in database creation of MGNREGA assets.

Hon'ble Prime Minister during a review meeting had underlined for online recording and monitoring of assets to check leakages and for effective mapping of terrain for future developmental works. In view of such a mammoth scale envisaged, a systematic procedure is embarked upon for the creation of a database on these assets. The approach adopts technological interventions in terms of using mobile based geo-tagging and a Geographical Information System (GIS) based information system.

Geo-tagging exercise is a national level initiative involving linking ISRO-Bhuvan with "NREGA-Soft" interface operated under DoRD by National Informatics Centre (NIC). This has to be established within a very limited time-line, which will enable access to all state implementing departments. Database of completed assets residing on "NREGA-Soft" will be pushed to Bhuvan, which in turn will be served to each data collector under Gram Panchayats. Collected data will be moderated for quality level through approved authorities at block level to ensure the precise information for online visualisation. Bhuvan can facilitate a complete geographic information storage, retrieval, analysis and reporting for completed assets, with a high resolution backdrop of Indian Remote sensing Satellite (IRS) natural color images. DoRD and NRSC are closely working out the modalities of design, integration and roll out based on intensive schedules seeking compliance of high rigor.

Geo-tagging initiative of MGNREGA assets at national level was rolled out by Shri Narendra Singh Tomar, Hon'ble Union Minister of Rural Development on November 30, 2016 at New Delhi. This was a historic moment in the progress of MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act). MGNREGA is one of the important flagship programs for rural development in the country. It aims to create meaningful and qualitative job opportunities for rural landless population. Rural employment creation is the vital process in mitigating economic weakness of rural poor.

Remote Sensing (RS) and Geographical Information System (GIS) can be effectively used to collect, store and analyse Mahatma Gandhi NREGA assets (watershed locations, farm ponds, percolation tanks, check dams, road layer, irrigation channels, etc.). With the use of GIS in the area of asset management, it is possible to visualise and understand the geographical context of an asset and improve the efficiency of asset management. Application of GIS in MGNREGA projects can help in tracking MGNREGA works through Geo-tagging techniques and by reporting the location-specific information with respect to time.

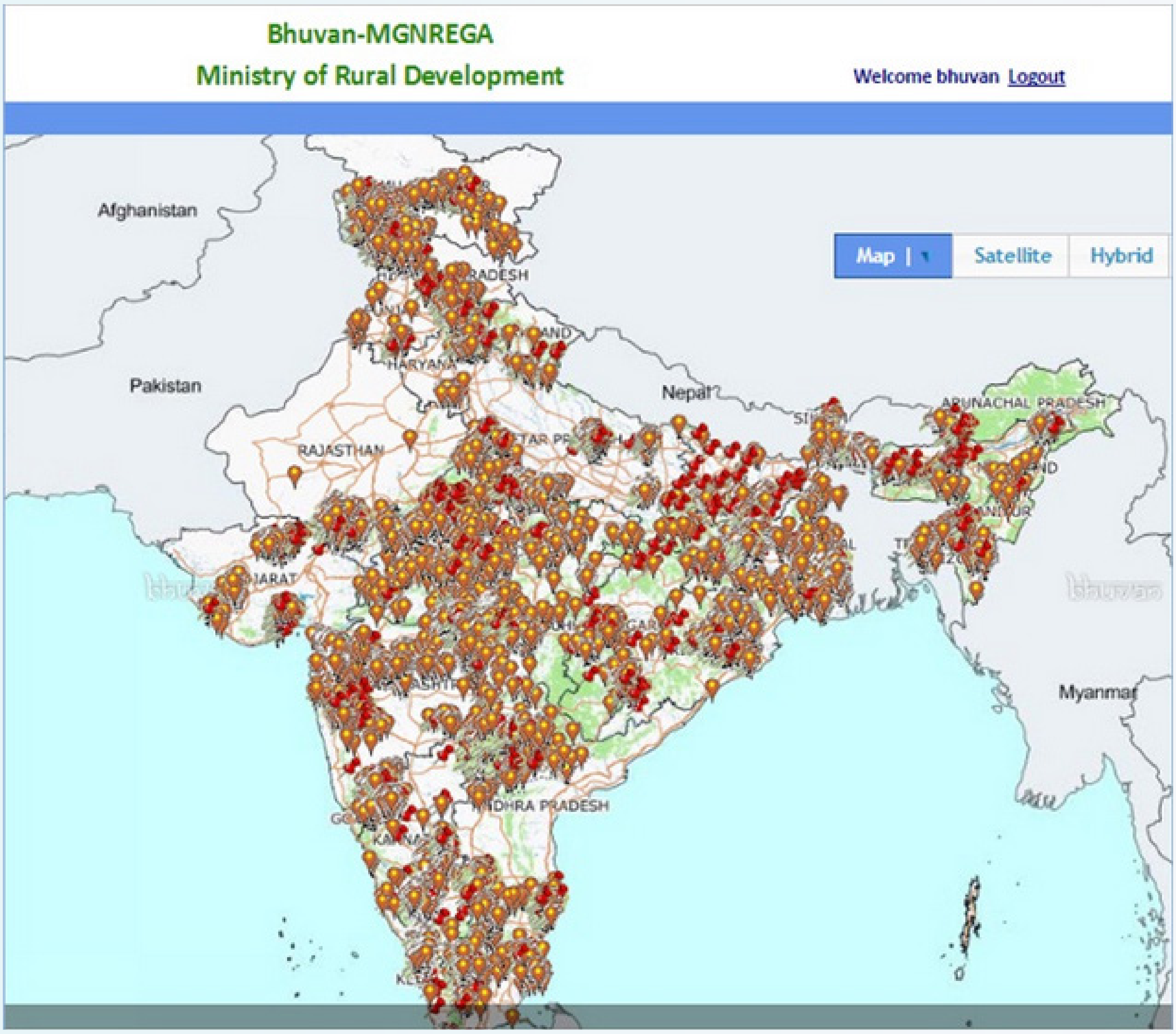
Spatial location is a major common aspect of all the asset data and GIS can map all the assets along with information for visualisation and proper decision-making. The Geo-tagging of Assets under MGNREGA has been done by adopting technological solutions using GPS based location information through Mobile Apps and depicting the field information on Bhuvan Geoportal. This technology enables precise monitoring and assessment of the progress in assets creation, while bringing in transparency and good governance. Ministry of Rural Development (MoRD) has adopted this approach in the creation of assets database, that would provide rich dividends in the long run with respect to the project management and maintaining assets. The Linkages established between NIC server and NRSC Geospatial Servers to provide the state-of-the-art WebGIS solution is the unique achievement of this initiative.

Earlier, a Memorandum of Understanding (MoU) was signed between the Department of Rural Development (DoRD), MoRD, New Delhi and National Remote Sensing Centre (NRSC), ISRO, Hyderabad, for Geo-tagging of the assets created under MGNREGA, on June 24, 2016. Subsequently, Bhuvan Capacity building towards MGNREGA was held on July 29, 2016. A "Geo-tagging Application" was inaugurated as part of National Orientation workshop held during August 2016. Later, 'Rollout in 88 districts

Geo-tagging' was held for Geo-tgging and monitoring through web Geoportal with a detailed help manual.

Shri.Narendra Singh Tomar, Minister of Rural Development following the inauguration, emphasised the value of the national rollout event as a historic moment in the progress of MGNREGA. He underlined the role of space technology applications in realising an inventory of 6.5 lakh assets over the entire country and optimistic about the Geo-tagging of completed assets since its inception.

Other dignitaries who graced the occasion are Dr Jitendra Singh, Minister of State, PMO, Space and Atomic Energy, Shri Ram Kripal Yadav, Minister of State for Rural Development, Shri A.S. Kiran Kumar, Chairman ISRO/ Secretary, Dept of Space, and Shri Amarjeet Sinha, Secretary, Ministry of Rural Development. Officials from State Rural Development, NIRD, NIC, NRSC, DoRD, etc., also participated in the event.



Geographical Distribution of Assets Geo-tagged

ISTRAC Celebrates Ruby Year

ISRO Telemetry Tracking and Command Network (ISTRAC) was established on September 06, 1976 for facilitating to-and-fro communication conduit for launch vehicles and satellites of ISRO, in addition to carrying out satellite mission operations. Since then, its growth is in tune with the developments around the world. ISTRAC made a humble beginning from TERLS to support RH-series missions in 1970 and Aryabhata in 1975 through P/VHF bands from SHAR. ISTRAC has emerged as a world class ground support provider, having a state-of-the-art TTC Network, Deep Space Network (DSN), TTC Network Control Centre, Mission Operations Complex and Space Science Data Centre. It is also responsible for operating the ISRO Navigation Centre, Search and Rescue - Disaster Management (SAR-DMS) operations, Hub for Space-based services, Radar Development for launch vehicle tracking and Weather Forecasting.

Car Nicobar down range station was established in 1975 and successfully supported all SLV missions. During 1976, a Satellite Tracking And Ranging Station (STARS) was established at Kavalur with Ruby Laser Radar and an Optical Tracking Camera. In 1978, a Very High Frequency (VHF) system was established at Ahmedabad to support Bhaskara missions that provided additional data for updating the orbital elements. The launch of APPLE in 1981 brought in a major improvement in TTC and mission support. New C-Band terminals were realised at SHAR and Ahmedabad to support the normal phase of the mission. In order to have additional contact with the satellites as well to obtain more tracking data, external network stations of RSA, CNES and DLR were utilised.

A major decision was taken in 1982 to shift the frequency of operations for both the launch vehicles and satellites to S-Band. Towards catering to ASLV / PSLV / IRS Projects, ISTRAC proposed and augmented the TTC network under ISTRAC Expansion Project, namely, launch base TTC station with redundancy at SHAR, a down range station at Car Nicobar, intermediate down range station at Thiruvananthapuram, a down range station at Mauritius and a station at Lucknow, specifically to support IRS Missions.

In 1984, ISTRAC became a unit of ISRO and shifted to Bangalore towards establishing a Spacecraft Control Centre with associated TTC stations and computer systems for supporting the IRS missions. This major task was undertaken by ISTRAC and established in time for the launch of IRS-1A on March 17, 1988. Also, a station for South-bound PSLV launches was established at Mauritius in 1986. To take care of flame attenuation at the SHAR station, an 8 Meter S-Band antenna was established at Thiruvananthapuram in 1987. Also, 2 x 10M S-band terminals were established at Bangalore and Lucknow each and one at Mauritius. The Car Nicobar station was shifted to Port Blair during 1995 after closure of the ASLV project.

ISTRAC could establish eight S-band TTC stations at geographically spread locations in a period of ten years. Today, ISTRAC has become a repository of domain knowledge and ready to take up various diversified activities. Also, during 1997, ISTRAC facilitated a satellite-based communication Demand Assigned Multiple Access (DAMA) network, interconnecting various units of ISRO.

In order to meet the continuous Telemetry requirements of GSLV, an intermediate down range station at Brunei and a down range station at Biak (Indonesia) were established during 1998 that continued to serve all East-bound PSLV/GSLV Missions. As Biak station has some exclusive passes that are not visible to Indian stations, it is optimally utilised to support the satellite operations as well. The initiation of ISTRAC Network Modernisation (in 2 phases) during the year 2000, brought in the state-of-the-art systems with miniaturisation and multi-functional capabilities, paving the way for automated network control. The second S/C-Band terminal was put up at Biak during 2005 to support Launch and Early Orbit Phase (LEOP) operations of GEO Missions. Also, during this period, fully automated VHF terminals were established at low-cost to support HAMSAT Mission. In 2006, the upgradation of Bangalore and Lucknow S/X terminals from 3.7 M to 11 M terminal was completed. And, a new 11 M S-Band TTC terminal was established in MOX complex during 2007 towards support of Cartosat missions.

Establishing the ground segment for Chandrayaan-1 mission was the biggest challenge for ISTRAC. An 18 metre S-Band DSN antenna was installed to support Chandrayaan-1 mission during 2007 and the indigenous 32 meter S/X-Band deep space antenna was realised in 2008 with a record time of just two years. The Indian Space Science Data Centre became the focus of all lunar science activities. A 11 M S/X-Band antenna has been established for the exclusive support of ASTROSAT Mission in the Indian Deep Space Network (IDSN) complex during the same period. 2009 saw an S/X second terminal at Mauritius for payload data reception and SHAR / Thiruvananthapuram antennas were upgraded with 11 M antennas. ISTRAC Transportable Terminals supported PSLV-C19/RISAT (2012), PSLV-C25/ MOM (2013) and PSLV-C34/Cartosat-2 series satellite mission (2016) from Rodrigues / Pacific ocean / Rodrigues respectively. In both Chandrayaan-1 and MOM missions, the man – machine endurance was successfully tested.

The existing Spacecraft Control Centre of the 80s was configured to support a main satellite and a co-passenger. As the satellites grew with complexity and in quick succession, new control centres had to be established and thus sophisticated Mission Operations Complex MOX-1 (2008) and MOX-2 (2010) were realised in a separate campus which can support dual launch missions simultaneously. The automation of satellite operations has brought in a sense of secured monitoring and control of the satellites. Currently, ISTRAC handles 15 satellites and ensures their services. And to take care of any exigencies ISTRAC has established an alternate control centre at Lucknow and IDSN.

ISTRAC has so far supported 64 of launch vehicle/ satellite missions. ISTRAC provided TTC support for EUTELSAT Mission in 1990/91. It also contributed to the business of ANTRIX by providing TTC support to external agencies and supported two dozen missions so far.

On the RADAR front, Doppler Weather Radars and C/S-Band tracking radars were designed, developed and operationalised by ISTRAC. The IRNSS Ground Segment is maintained by ISTRAC, helping to enable the critical IRNSS services. The search and rescue and disaster management facility at ISTRAC is providing reliable services to people under distress. The hub for the space-based services supports various societal applications such as Tele-Education, Tele-Medicine and Village Resources Centre (VRC).

Reliability and Quality Assurance (REQA) Group has focused its attention towards achieving high reliable operational support of the ISTRAC Ground Segment. It has established a Test Instrument facility at Bangalore for calibration of test instruments. It has achieved its excellences in providing calibration, incoming inspection and in-process inspection support for the various mission critical processes of ISTRAC.

ISTRAC Celebrated the Ruby Year on November 21, 2016 after completing 40 years of its existence. The evolution of ISTRAC from being a tracking station for the SLV/Aryabhata mission to a state-of-the-art ground support centre, capable of supporting complex missions like GSLV and Mars Orbiter Mission, is noteworthy. Prof Dhawan initiated the process of forming ISTRAC and subsequent Chairmen of ISRO and Directors nurtured ISTRAC in to a world-class Telemetry, Tracking and Command (TTC) service Facility and Satellite Operations Centre. At the Ruby day function organised at MOX, ISTRAC, Mr A S Kiran Kumar, Chairman ISRO and Secretary DOS delivered the Presidential Address and released the Souvenir. Mr KVVSSSR Anjaneyulu, Director, ISTRAC welcomed the invitees. Former Directors of ISTRAC, Mr K V Venkatachary, Dr. S Rangarajan, Dr S K Shivakumar and Mr. B S Chandrashekhar shared their experiences during the function.

Celebration of Ruby Year at ISTRAC

Asia-Pacific Space Leaders Forum for Disaster Risk Reduction

The Asia-Pacific Space Leaders Forum (ASLF) was organised in New Delhi on November 02, 2016, as a pre-conference event to Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR), by Indian Space Research Organisation (ISRO) and United Nations Economic Commission for Asia and the Pacific (UN-ESCAP). The focal theme of this event was 'Space+ for a resilient Asia and the Pacific'. It was attended by more than 20 space agencies of Asia and the Pacific.

The 20th Session of the Intergovernmental Consultative Committee (ICC) on Regional Space Applications Programme for Sustainable Development (RESAP) was held on October 31-November 1, 2016 as a preparation for the ASLF. ICC-20 drafted a new strategy for RESAP, as part of the new Asia-Pacific Plan of Action 2018-2030 that will be taken from APSLF through AMCDRR to the 3rd Ministerial Conference on Space Applications to be convened in 2018.

The deliberation took place on the effective use of space applications for further implementation of the Sustainable Development Goals (SDGs), focused on reducing the risk and impact of natural disasters as a part of the Forum. Space leaders acknowledged the potential of Space technology applications in supporting the implementation, follow up and review of the Sendai Framework of Disaster Risk Reduction.

Space leaders offered their support to strengthen regional cooperation by providing space inputs for disaster preparedness, early warning alerts for impending disasters, allowing the modelling and forecasting of different disaster scenarios, and providing timely geo-spatial information & services that can save lives during emergencies and monitor redevelopment efforts to achieve resilience and build capacity to better manage disaster risks.

They also recognised the need to strengthen the Regional Space Applications for Sustainable Development in Asia and the Pacific (RESAP) and outlined a new vision for an Asia-Pacific Plan of Action for Space Applications 2018-2030.

The Forum requested the ESCAP Secretariat to work in consultation with its member States and stakeholders to present the new Asia-Pacific Plan of Action for Space Applications for discussion at the respective ESCAP inter-government committees next year, as well as at the next Asia-Pacific Forum on Sustainable Development (APFSD). The Plan of Action also contributes to the regional road map for the implementation of the 2030 Agenda on Sustainable Development.

Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR) 2016 organised a Featured Event on Nov 4, 2016 on the "Application of Science & Technology for prevention of New Risks". The event deliberated on the urgent need for a stronger science-policy interface towards science-based policy development in DRR. The outcome of the session was a set of recommended actions that will be followed by the Asian science, technology and academia community as well as Government organisations.

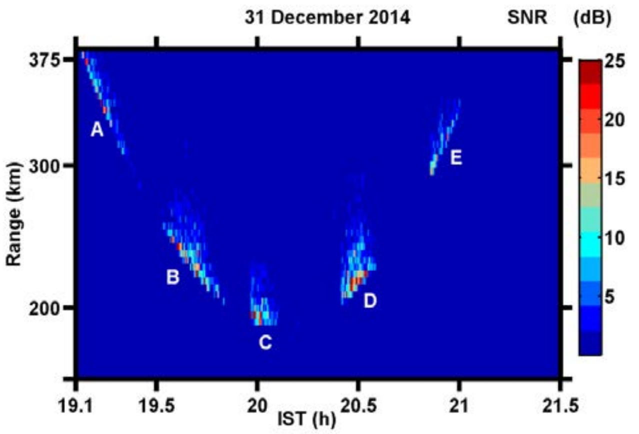
NARL MST Radar Observes Echoes from the Moon

The high power, large aperture Mesosphere-Stratosphere-Troposphere (MST) Radar established at National Atmospheric Research Laboratory (NARL), Gadanki nearly two and half decades ago was designed to study the middle and upper atmospheric dynamics. This radar has now been successfully employed to detect the moon echoes, providing opportunity of probing planetary bodies, a new dimension of future research activities from NARL. The detection of moon echoes also provides an opportunity to characterise the large phased array antenna system including the calibration of the radar.

Since the moon is about 3,68,000 km away from the earth, the RF pulse has to travel for ~2.5 seconds to return to the radar from the moon's surface. Since the primary design of the radar was not meant to study the moon, an experiment was conducted cleverly in range-ambiguous mode in such a way that the range folded echoes from the moon fell in the height region where apparent source of atmospheric echoes were absent. The radar beam was positioned at 18° East, 12° East, 6° East, Zenith, and 6° West sequentially so as to receive moon echoes while it was apparently transiting from East to West. Due to the finite beam width (2.8°) of the antenna pattern and the apparent angular dimension of the moon is about 0.5°, the transit time of the moon across the antenna beam is estimated to be about 15 minutes. Observations were made for 26 minutes at each beam position in order to detect echoes beyond the half power beam width of the antenna radiation pattern.

The experiment was successful and an example of moon echoes observed in different directions in the form of range-time variations of Signal-to-Noise Ratio (SNR) is shown in the figure. In this Figure, the true range ≈ observed range + 3,67,740 km. Salient results obtained are:

- The moon echoes are found to have SNR as high as 20 dB
- echo power changes as the radar pulse travels from the sub-terrestrial point towards the limbs consistent with the angular dependence of echo power
- Doppler spectral property changes from narrow single peak spectrum to multi-peak spectrum as the radar pulse travels from the sub-terrestrial point towards the limbs
- Multi-peak spectra are found to be originating from multiple discrete targets on the moon



SNR of moon echoes as a function of ambiguous-range and time observed in different beams. Echoes marked as A, B, C, D, and E correspond to observations made in 18° East, 12° East, 6° East, Zenith, and 6° West beams, respectively

First results from the moon echo experiments conducted using the MST radar are in agreement with those reported earlier at similar frequencies. The strong signals with narrow spectral features have been attributed to radar returns at normal incidence from places close to the sub-terrestrial point on the moon while the weak echoes with relatively broad spectral features have been attributed to discrete multiple scattering centers along the limb, which have also been confirmed by higher-order spectral analysis.

Radar techniques have been extensively used for studying the moon ever since the radio signals reflected from the moon were detected using ground-based radar. Both earth-bound and satellite-based radar techniques have since been employed for probing the moon's surface topography, impact craters morphology, and regolith. Most of the radar observations for studying the moon, however, have been made at centimeter wavelengths except for a few which were done from the earth in the meter-decameter wavelength. Radar experiments at meter-decameter wavelengths provided important information on the wavelength dependence of radar cross section and angular dependence of backscattering, which were used for characterising lunar surface properties, regolith and underneath rocks.

It is planned to employ the delay-Doppler technique on the MST radar for mapping the moon's surface, which would be a reality in the near future once the active array MST radar project is upgraded for incoherent scatter radar applications. Such observations then can be compared with those of Mini-SAR onboard Chandrayaan-1 not only to understand the moon surface but also to study the Very High Frequency (VHF) echoes from the moon and the ionospheric effects on radio experiments.

Indian Space Science Data Centre - ISSDC

The Indian Deep Space Network (IDSN), commissioned during the year 2008, at Byalalu village near Bengaluru, forms the Ground segment for providing deep space support for India's Space Science Missions like Lunar mission-Chandrayaan-1, Mars Orbiter Mission (MOM) etc., Indian Space Science Data Centre (ISSDC), located at the IDSN campus, is the primary data centre for data archives of Indian Space Science Missions.

IDSN complex comprises of Deep Space Antennas of 18 m and 32 m capable of supporting interplanetary missions. It also houses 11 m antenna facility to support earth bound scientific missions. The 32 m fully steerable antenna (DSN32) with beam wave-guide, operating in S and X-band and 18 m fully steerable antenna offer excellent facilities for supporting International Deep Space Missions. The 32 m antenna was indigenously realised with the collaboration of ECIL, Hyderabad, BARC, Mumbai and other Indian Industries. DSN32 consists a Servo system for precise antenna pointing and tracking with a speed as low as 0.1 milli-deg/sec. The cryogenically cooled low noise amplifier system of DSN32 makes it capable of receiving extremely week signals from the satellite. The timing system of the antenna consists of an active Hydrogen maser for highly accurate and stable clock.

The ISSDC is designed to host the science data archives and the custodian of all the science data from the Indian science missions and has a state-of-the-art infrastructure to cater to the needs of planetary, interplanetary, scientific and outer space missions. This facility is built on the earthquake resistance site. Considering the long time preservation requirement, for catering to the needs of all ISRO space science missions, a hierarchical storage management is used. At present, ISSDC is supporting MOM apart from AstroSat and Megha-Tropiques.

Presently, ISSDC is involved in the following major activities:

- In AstroSat, ISSDC has played major role in bringing all the scientific institutions such as Tata Institute of Fundamental Research (TIFR), Raman Research Institute (RRI), Indian Institute of Astrophysics (IIA), and Inter-University Centre of Astronomy and Astrophysics (IUCAA) to a nodal place for the harvesting of scientific data from AstroSat. At present, various activities are happening at this centre in engaging the Scientists and general public for the data utilisation from AstroSat.
- In Megha-Tropiques, ISSDC is acting as real-time processing centre to provide the data needs of weather forecasting and atmospheric modeling institutes in India, France and USA. ISSDC has played an important role in the operationalisation of Systems Applications and Products (SAP) data.

On the occasion of two year completion of MOM, ISRO released the first year (September 2014 to September 2015) data sets to the public through ISSDC website. 1603 products from all the five instruments of MOM were hosted and received overwhelming response. 1,100 users registered till December 2016 and downloaded about 200 Gb data.

ISSDC has the major challenges ahead to provide mission support for the upcoming lunar mission Chandrayaan-2, Solar mission Aditya-L1 and other future planetary and scientific missions of ISRO. To cater to the needs of a variety of missions, ISSDC has the state-of-the-art infrastructure of Storage, Processing Servers, Communication Network and advanced computation applications.

Panoramic View of ISSDC

PSLV-C36 Successfully Launches Resourcesat-2A

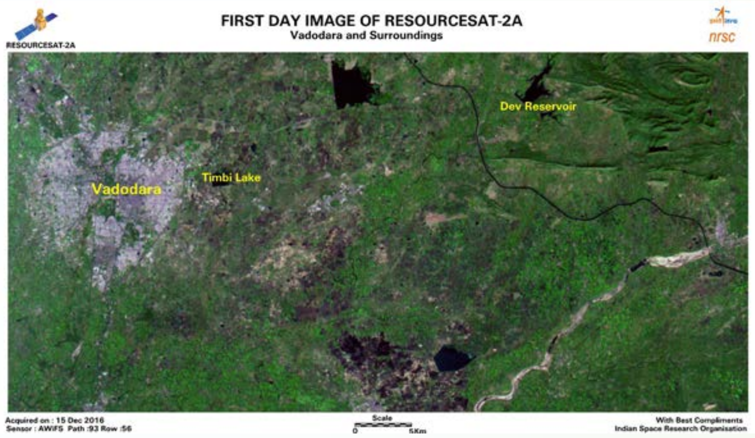
In its 38th flight, ISRO's Polar Satellite Launch Vehicle (PSLV-C36) successfully launched the 1,235 kg Resourcesat-2A, Remote Sensing Satellite on December 07, 2016 from Satish Dhawan Space Centre SHAR, Sriharikota. This was the 37th consecutively successful mission of PSLV.

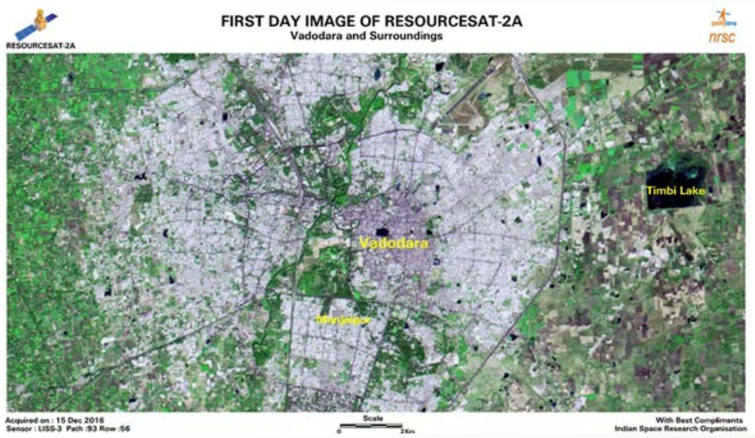
After PSLV-C36 lift-off at 10:25 hrs IST from the First Launch Pad with the ignition of the first stage, the subsequent important flight events, namely, strap-on ignitions and separations, first stage separation, second stage ignition, payload fairing separation, second stage separation, third stage ignition and separation, fourth stage ignition and cut-off, took place as planned. After a flight of 17 minutes 05 seconds, the vehicle achieved a polar Sun Synchronous Orbit of 824 km height inclined at an angle of 98.725 degree to the equator (very close to the intended orbit) and 47 seconds later, Resourcesat-2A was separated from the PSLV fourth stage.

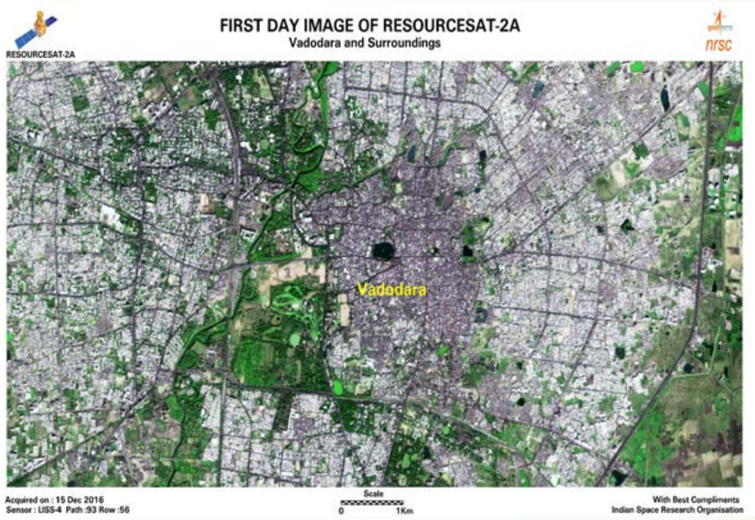
After separation, the two solar arrays of Resourcesat-2A deployed automatically and ISRO's Telemetry, Tracking and Command Network (ISTRAC) at Bengaluru took over the control of the satellite. Subsequently, the satellite was brought to its final operational configuration following which it began providing imageries from its three cameras. The data sent by Resourcesat-2A are useful for agricultural applications like crop area and crop production estimation, drought monitoring, soil mapping, cropping system analysis and farm advisories generation.

Like its predecessors Resourcesat-1 and 2, Resourcesat-2A has a unique 3-Tier imaging system with Advanced Wide Field Sensor (AWiFS), Linear Imaging Self Scanner-3 (LISS-3) and Linear Imaging Self Scanner-4 (LISS-4) cameras. The AWiFS provides images with a sampling of 56 metres, a swath of 740 km and a revisit of 5 days whereas the LISS-3 provides 23.5 metres sampled images with 141 km swath and a repitivity of 24 days. LISS-4 provides 5.8 metres-sampled images with 70 km swath and a revisit of 5 days.

With this launch, the PSLV yet again demonstrated its reliability. The total number of satellites launched by India's workhorse launch vehicle PSLV including Resourcesat-2A reached 122, of which 43 were Indian and the remaining 79 from abroad.







India's Communication Satellite GSAT-18 Launched Successfully

India's communication satellite GSAT-18 was launched successfully by the European Ariane5 VA-231 Launch Vehicle on October 06, 2016. The 3404 kg GSAT-18 carries 48 communication transponders in C-band, upper extended C-band and Ku-band for providing various services to the country.

After a smooth countdown, the Ariane-5 Launch Vehicle lifted off right on schedule at 0200 hrs IST on October 06, 2016. After a flight of 32 minutes and 28 seconds, GSAT-18 separated from the Ariane 5 upper stage in an elliptical Geosynchronous Transfer Orbit (GTO) with a perigee (nearest point to Earth) of 251.7 km and an apogee (farthest point to Earth) of 35,888 km, inclined at an angle of 6 degree to the equator.

ISRO's Master Control Facility (MCF) at Hassan in Karnataka took over the command and control of GSAT-18 immediately after its separation from the launch vehicle. Preliminary health checks of the satellite revealed its normal health.

Subsequently, the orbit raising manoeuvres were performed to place GSAT-18 satellite in the Geostationary Orbit (36,000 km above the equator) by using the satellite's propulsion system in steps.

After the completion of orbit raising operations, the two solar arrays and both the antenna reflectors of GSAT-18 were deployed. Following this, the satellite was put in its final orbital configuration. GSAT-18 was positioned at 74 deg East longitude in the geostationary orbit and co-located with the Indian operational geostationary satellites. Later, communication payloads of GSAT-18 were turned on. After the successful completion of all the in-orbit tests, GSAT-18 was made ready for operational use.

GSAT-18

GSAT-18 is a communication satellite configured around I-3K extended bus with a lift-off mass of 3404 Kg and ~ 6 KW power generation capacity. The satellite carries Ku, Normal C and Extended C-band transponders. It also carries Ku-band beacon to help in accurately pointing ground antennas towards the satellite. GSAT-18 is aimed at providing continuity to the communication services in the country and intended to replace INSAT satellites which will be reaching their end-of-mission-life. It is designed for a mission life of more than 15 years.

GSAT-18 undergoing Reflector Deployment Test

AstroSat Completes One Year in Orbit

The Indian multi-wavelength space astronomy observatory AstroSat has completed one year in orbit on September 28, 2016. During this time, the spacecraft orbited the Earth more than 5400 times and has executed 343 individual pointings to 141 different cosmic sources. During this scientifically rewarding one-year, several celestial sources were observed and studied in detail. A science meet was organised at IUCAA on September 29, 2016 to commemorate the one year completion of AstroSat.

AstroSat observes the Universe in optical, near and far Ultraviolet and X-ray regions of the electromagnetic spectrum. The interesting feature of AstroSat is the simultaneous multi-wavelength capability on the same satellite platform. These studies are being extended by co-coordinated observations using other spacecraft and ground based observatories.

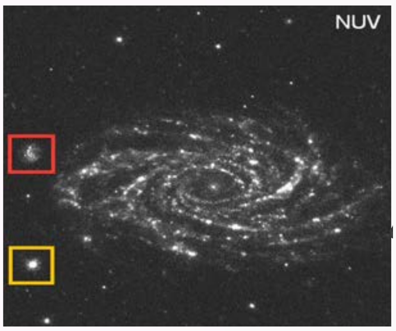
Some of the salient science observations are:

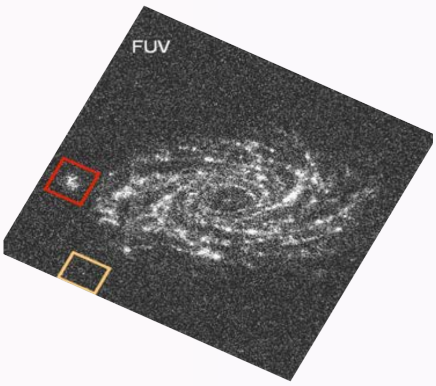
- Large Area X-ray Proportional Counter (LAXPC) observed rapid variability of high energy (particularly >20keV) X-ray emission from a black hole system GRS 1915+105 for the very first time. LAXPC, also measured the arrival time difference between the high and low energy X-rays (which is of the order of tens of milli-seconds). This provides direct clues to the geometry and dynamic behavior of the gas swirling around a spinning black hole.
- The Cadmium Zinc Telluride Imager (CZTI) normally operates in the energy range 15 – 100 keV. At higher energies, the Field of View of this imager becomes wide and therefore it can detect Gamma Ray Bursts (GRBs). CZTI detected over 40 GRBs and demonstrated its capability to detect polarisation in GRBs. Polarisation properties and their relation to the spectral evolution have the potential to clearly distinguish between various models of GRB prompt emission mechanism. Polarisation estimates are being undertaken for Crab and several other X-ray sources.
- Ultraviolet Imaging Telescope (UVIT) observed the field stars in the open cluster NGC 188. One source, which was earlier thought to be a sub-dwarf, is found to be a binary with sources having temperatures around 12500K and 5750K.
- Scanning Sky Monitor (SSM) observed the X-ray pulsar 4U0115+63 in its outburst phase and the pulsations of 3.6 seconds were detected.
- Soft X-ray Telescope (SXT) detected the continuum and lines from bright Supernova Remnant such as Tycho. The advantage of having a good spectral resolution along with large field of view is expected to be extremely important to study the clusters of galaxies.

Regular Satellite Tracking and data processing is being done at ISRO. The data is distributed to the scientific community by the Indian Space Science Data Centre (ISSDC).

An Announcement of Opportunity (AO) was made in June 2016 through ISRO website, for Indian scientists/ researchers working at institutes/universities/colleges to submit proposals.

ISRO, in collaboration with IUCAA, has established an AstroSat Support Cell (ASC) at IUCAA, Pune, which was formally dedicated to the scientific community by Chairman, ISRO on the occasion of one year completion of AstroSat.





Galaxy NGC 2336 imaged by UVIT on-board AstroSat in near UV and far UV

PSLV-C35 Successfully Launches Eight Satellites into Two Different Orbits in a Single Flight

In its thirty seventh flight (PSLV-C35), ISRO's Polar Satellite Launch Vehicle successfully launched the 371 kg SCATSAT-1 Satellite along with seven co-passenger satellites on September 26, 2016 from Satish Dhawan Space Centre SHAR, Sriharikota. This was the thirty sixth consecutively successful mission of PSLV. The total weight of all the eight satellites carried on-board PSLV-C35 was 675 kg. PSLV-C35 is the first PSLV mission to launch satellites carried onboard into two different orbits. This PSLV mission was the longest of the PSLV missions conducted till date and was completed in 2 hours 15 minutes and 33 seconds after lift-off.

After PSLV-C35 lift-off at 0912 hrs IST from the First 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, payload fairing 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 56 seconds, the vehicle achieved a polar Sun Synchronous Orbit of 724 km inclined at an angle of 98.1 degree to the equator (very close to the intended orbit) and 37 seconds later the primary satellite SCATSAT-1 was separated from the PSLV fourth stage.

After separation, the two solar arrays of SCATSAT-1 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 started providing weather related services using its scatterometer payload. The data sent by SCATSAT-1 satellite are helping weather forecasting services to user communities through the generation of wind vector products as well as cyclone detection and tracking.

After the successful separation of SCATSAT-1, the PSLV-C35 mission continued. Still carrying the seven co-passenger satellites, the fourth stage of PSLV coasted over the South polar region and then started ascending towards the Northern hemisphere. A safe distance between the orbiting SCATSAT-1 and PSLV-C35 fourth stage was maintained by suitably manoeuvring the stage.

At 1 hour 22 minutes and 38 seconds after lift-off as the fourth stage was in the North polar region, the two engines of PSLV fourth stage were reignited and fired for 20 seconds. As a result of this, it entered into an elliptical orbit measuring 725 km on one side of the Earth and 670 km on the other.

And 50 minutes later, as the PSLV fourth stage was again coasting near the south pole, its engines were fired for another 20 seconds. This second firing made the fourth stage to enter into a circular orbit of 669 km height inclined at an angle of 98.2 degree to the equator.

37 seconds later, the Dual Launch Adapter was successfully separated from the PSLV-C35 fourth stage. 30 seconds after this event, ALSAT-1N was the first co-passenger satellite to be separated successfully. Following this, the NLS-19, PRATHAM, PISAT, ALSAT-1B, ALSAT-2B, and Pathfinder-1 were separated from the PSLV fourth stage in a predetermined sequence thereby successfully completing PSLV-C35 mission. Of the seven co-passenger satellites carried by PSLV-C35, two – PRATHAM weighing 10 kg and PISAT weighing 5.25 kg – were

Panoramic View of PSLV-C35 at First Launch Pad

University/Academic institute satellites and were built with the involvement of students from IIT-Bombay and PES University, Bengaluru and its consortium, respectively.

The remaining five co-passenger satellites for international customer satellites included three from Algeria (ALSAT-1B, ALSAT-2B and ALSAT-1N), one from Canada (NLS-19) and one from United States (Pathfinder-1).

With this launch, the PSLV's capability to launch satellites into two different orbits was successfully demonstrated. The total number of satellites launched by India's workhorse launch vehicle PSLV reached 121, of which 42 are Indian and the remaining 79 were from abroad.

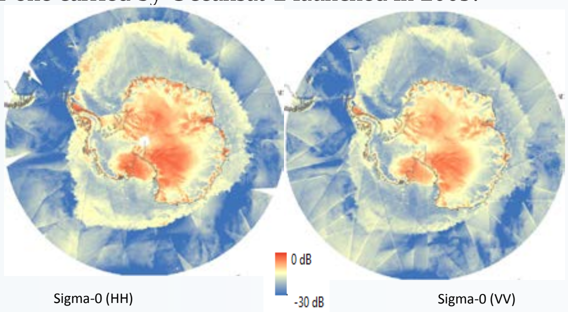
SCATSAT-1 undergoing a pre-launch test

SCATSAT-1 – Satellite for Weather Forecasting, Cyclone Detection and Tracking

Global wind data, which is very crucial for cyclone detection and weather forecasting applications, was gathered by Scatterometer instrument flown as one of the payloads in OCEANSAT- 2 satellite. This data was utilised by national and international users and proved to be a very important tool for oceanographic studies. SCATSAT-1 is the continuity mission for Scatterometer payload carried by the earlier Oceansat-2 satellite.

The magnitude and direction of the wind vector at the ocean surface is a key parameter for weather prediction as well as detection and tracking of cyclones. The objectives of SCATSAT-1 are to facilitate the weather forecasting services to the user communities through the generation of wind vector products. The Ku-band Scatterometer payload carried by SCATSAT-1 has enhanced features compared to the similar one carried by Oceansat-2 launched in 2009.

SCATSAT-1 is built around ISRO's small satellite 'IMS-2 BUS' and the mass of the satellite is 371 kilograms. The satellite is working in sun synchronous orbit of 720 km. altitude with an inclination of 98.1 deg. This is be a polar orbiting satellite and takes two days to cover the entire globe. The expected life span of the satellite is 5 years with non-stop 24 X 7 all weather operations. Wind speed is measured in the range of 3m/s to 30m/s and 0-360 deg directions. Finally wind vector grids of 25 kms*25 kms over oceans are generated for the entire globe.



Antarctic as observed by Scatsat-1, October 03-04, 2016

The satellite is carrying a Ku-band Scanning Scatterometer radar instrument operating at 13.515 GHz similar to the instrument flown onboard Oceansat-2. The payload instrument is be a vital tool globally used to study wind patterns above the ocean, air-sea interactions, ocean circulation and their overall effects on weather patterns. Climate quality data is expected to be obtained from this spacecraft to provide accurate knowledge regarding Himalayan ice formation and melting, cyclones formation near Indian coastal line, Greenland ice melting, etc.,

Scatterometer operates on the principle of radar. When the radar radiates energy pulses towards the ocean's surface, a backscatter effect is produced due to interaction between electromagnetic waves and sea surface waves, which is a function of speed and direction of surface winds over the oceans.

This process of receiving back-scattered signal is carried out while conically scanning or rotating the antenna along with the motion of the satellite giving a swath of 1400 km. The collected data is processed onboard to generate the estimate of backscattered power/signals and stored on a data recorder. This recorded data is then transmitted to a ground station and later converted into wind vectors for the global user.

These wind vectors will help meteorologists in accurately predicting the cyclone formation, its movement and estimated landfall. It may be recalled that Ocean wind vectors data helped in accurately predicting cyclone 'Phailin' in the Odisha coast in 2013, which helped in mitigation and saving of human life and livestock.

SCATSAT-1 is a global mission and data generated from the Scatterometer, developed by ISRO will also be utilised by the American space agency NASA and European Space Agency organisation, EUMETSAT to provide global weather data to all those involved in weather studies and global climate change studies.

SCATSAT-1 Wind Products (BETA Version) Released

SCATSAT-1 was launched on September 26, 2016 and was injected into 720 km orbit with the required inclination of 98°. The satellite was put into the orbit at 9:30 AM local time and then was slowly allowed to drift and it is arrested to 8:45 AM local time. Ku-band Scatterometer of SCATSAT-1 is the main sensor on board this satellite and the data is very useful for Atmospheric and Oceanographic Applications. The Scatterometer payload of SCATSAT-1 is identical to OSCAT payload of Oceansat-2. Back scatter coefficient (sigma – 0) and Wind products are the main products from this satellite.

The objectives of SCATSAT-1 Mission are:

- ► To design, develop, launch and operate a state of art three axis body stabilised satellite providing ocean based remote sensing services to provide continuity of weather forecasting services to the user community
- ► To develop remote sensing capability with respect to global day and night weather forecasting
- ► To establish a ground segment to receive and process the payload data at a specified turn around time to meet the requirements of the user community
- ► To develop related algorithms and data products at 50 km X 50 km and 25 km X 25 km grids to serve the well-established application areas and also to enhance the mission utility

Data Processing:

There are 14 to 15 orbits data available daily from SCATSAT-1 satellite. The data is being downloaded daily at Shadnagar and Antarctica ground stations together for all the orbits. The downloaded data at Antarctica is being transferred to Shadnagar for further processing and dissemination. Chains to receive, process and disseminate data products are developed in Integrated Multi-mission Ground Segment for Earth Observation Satellites (IMGEOS) environment. The systems are designed in such a way that the same can be used for future SCATSAT missions too.

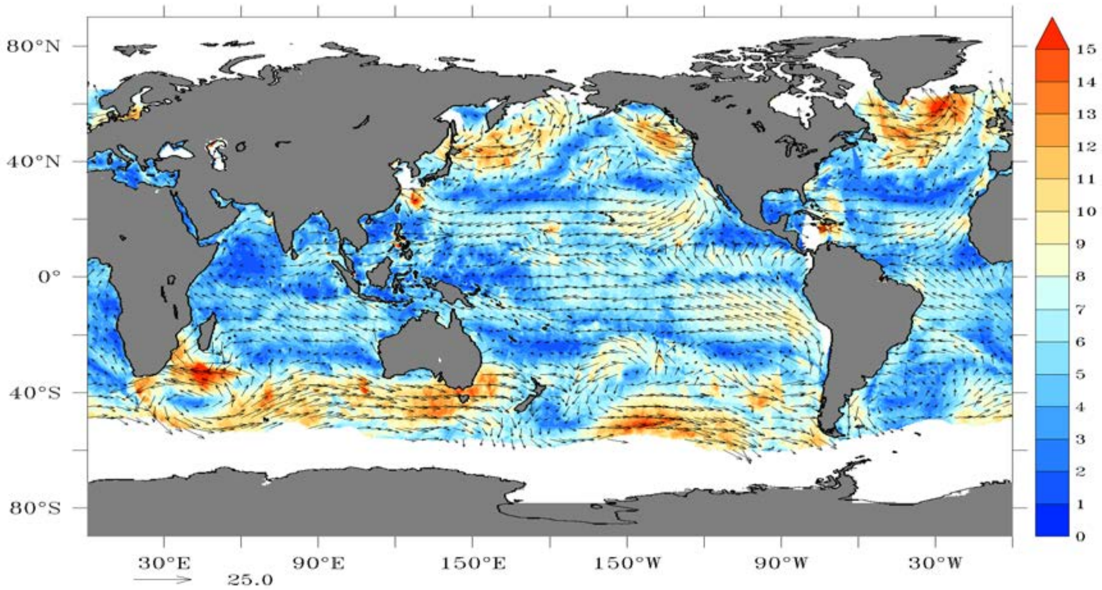
Scatterometer provides back scatter coefficients over the oceans. With these values, sigma – 0 and wind vectors of the entire globe are getting computed and corresponding HDF products are being generated. In contrast to OSCAT, here products are generated for pole to pole - North Pole (NP) to South Pole (SP) and SP to NP.

Different types of products are getting generated for 50 km and 25 km grid sizes. Level-2B, Level-3 products are planned to be provided to all users through internet. Level-1B and Level-2A products will be enabled for access only for specific users.

Data Dissemination:

Various types of products are planned to be disseminated through web portal and ftp server in near real time (within 50 minutes of data acquisition at Svalbard or Antarctica). Level-1B, Level-2A and Level-2B products will be supplied to specific users. Level-2B and Level-3 products will be uploaded onto ftp and web portal so that the users can download products in near real time mode.

Beta Version of SCATSAT-1 Wind Products were released to all the users for their research and feedback.



SCATSAT-1 Winds (m/s) Global Coverage October 03-04, 2016

Bengaluru Space Expo (BSX)-2016

Antrix Corporation Limited (ACL) and Indian Space Research Organisation (ISRO) in coordination with Confederation of Indian Industry (CII) organised the fifth edition of Bengaluru Space Expo (BSX) 2016 and a concurrent international conference on space business, "World Space Biz 2016" during September 1 – 3, 2016 at Bengaluru International Exhibition Centre (BIEC), Bengaluru. A Large number of delegates from industry from India and abroad, ISRO and foreign space agencies participated in the event. Delegates and visitors from 15 countries including USA, Japan, France, Australia, Switzerland, Taiwan, Russia and Ukraine attended BSX 2016.

There were seven sessions during the conference which focused on topics like Turnkey Satellite System Realisation, Tapping New Market for Satellite Sub-Systems, Launch Vehicle Productionisation through Industry, Connecting the Unconnected: Unlocking potential through High Throughput Satellites (HTS), NavIC and GAGAN: The Opportunities Ahead, GIS and Navigation: Enabling and Trends, Space Start Ups: The New Face of Industry. In addition, there were highlight addresses and lightning talks on futuristic communication by eminent industry professionals. The conference sessions were very fruitful with interactive discussions on many key topics of relevance to space. These topics of current interest ranged from Internet from Space, Connecting the Unconnected: HTS perspective, Marine Navigation: Find your Road in Sea, NavIC applications and Enabling Technologies to Eco System for Space Start Ups in India. The conference was well attended with active participation from the audience.

More than 70 exhibitors had their stalls at BSX 2016 including Airbus, JAXA, ECIL, Centum, Ananth Technologies, Data Patterns, Astra Microwave Products, Viasat, CNES, Swissnex, Asiasat and Measat. A large number of visitors from industry and academia apart from general public visited the exhibition.

Two new initiatives, a B2B meeting on "Small Satellites Development and Solar Panels" and "Satcom Services User Consultations" were organised during BSX 2016. The B2B sessions and user consultations with INSAT/GSAT Users of space segment capacity had a combined participation of more than 200 delegates from industry. Both these interactive sessions were well appreciated, with representatives actively engaging in discussions on the way forward and future plans for a mutually inclusive growth.

The trade exhibition conducted alongside the expo saw participation by various space industries from India and abroad as well as space agencies. Overall, the Expo conveyed the technology scenarios, challenges and opportunities in Space Business and was well received by the participants.

Inauguration of World Space Biz-2016

GSLV Successfully Launches India's Weather Satellite INSAT-3DR

In its tenth flight (GSLV-F05) conducted on September 08, 2016 India's Geosynchronous Satellite Launch Vehicle, equipped with the indigenous Cryogenic Upper Stage (CUS), successfully launched the country's weather satellite INSAT-3DR, into a Geosynchronous Transfer Orbit (GTO). The achieved orbit is very close to the intended one. The launch took place from the Second Launch Pad at the Satish Dhawan Space Centre SHAR (SDSC SHAR), Sriharikota, the spaceport of India. This was the first operational flight of GSLV equipped with CUS and the fourth to carry the indigenous CUS. This flight was the third consecutive success achieved by GSLV carrying indigenous CUS and the 2211 kg INSAT-3DR is the heaviest satellite was launched from the Indian soil.

After a 29 hour 40 minutes countdown, the 415 tonne, 49 m tall GSLV-F05 carrying INSAT-3DR, lifted off at the rescheduled time of 16:50 Hrs IST. The 40 minutes delay in the launch was due to an anomaly observed in the functioning of a pressure release valve in the liquid Oxygen filling ground segment which was resolved later.

Panoramic View of GSLV-F05 being moved from Vehicle Assembly Building (VAB) towards Launch Pad

At 4.8 seconds before the countdown reached zero, the four liquid propellant strap-on stages of GSLV-F05, each carrying 42 tonne of liquid propellants, were ignited. At count zero and after confirming the normal performance of all the four strap-on motors, the 139 tonne solid propellant first stage core motor was ignited and GSLV lifted off. The major phases of the flight included the core motor burn-out, strap on burn-out, ignition of the second stage, separation of the core motor together with strap-ons, payload fairing separation, second stage separation, CUS ignition and its timely shut down after satisfactory performance. About seventeen minutes after lift-off, INSAT-3DR was successfully placed in GTO.

In its oval shaped GTO, the INSAT-3DR satellite orbited the Earth with a perigee (nearest point to Earth) of 169.76 km and an apogee (farthest point to Earth) of 36,080.5 km with an orbital inclination of 20.62 deg with respect to the equator.

Soon after its injection into GTO, the solar array of INSAT-3DR was automatically deployed and the Master Control Facility (MCF) at Hassan in Karnataka took control of the satellite.

INSAT-3DR Satellite in clean room at Sriharikota

Like its predecessor INSAT-3D which is providing service from orbit since 2013, INSAT-3DR is an advanced meteorological (weather observation) satellite built by India to provide a variety inputs essential for accurate weather forecasting. For this, it is equipped with three payloads (instruments), namely, a Multispectral Imager, Sounder and weather Data Relay Transponder. INSAT-3DR also carries a satellite aided Search and Rescue Transponder that picks up and relays alert signals originating from distress beacons of maritime, aviation and land based users.

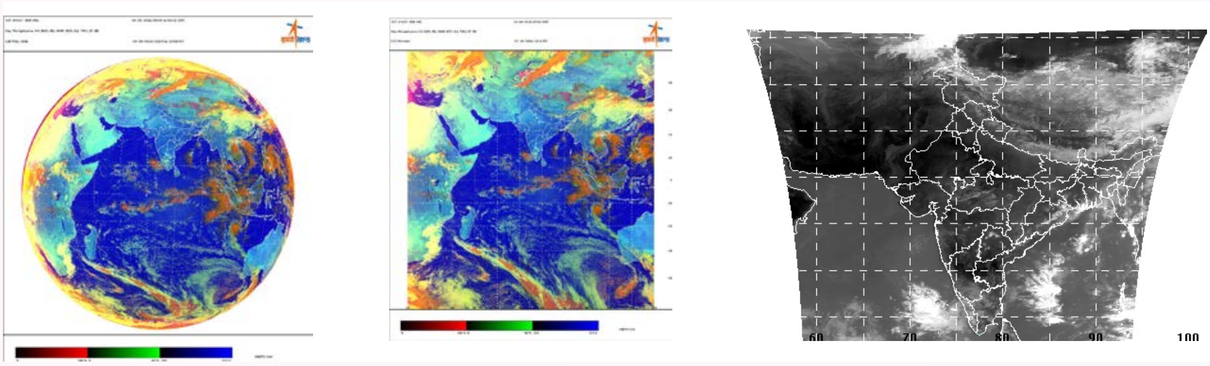
Subsequently, INSAT-3DR's orbit was raised from its GTO to the final circular Geostationary Orbit (GSO) by firing the satellite's Liquid Apogee Motor (LAM) in stages. The satellite was commissioned into service after the completion of orbit raising operations and the satellite's positioning in its designated orbital slot of 74 deg E longitude in the GSO and in-orbit testing of its payloads.

This flight of GSLV further highlighted the success of ISRO in mastering the highly complex cryogenic rocket propulsion technology.

INSAT-3DR Augments INSAT-3D for Improved Weather Monitoring and Prediction

Three-dimensional observations of atmosphere along with the land and ocean are required for various applications. One of the most important applications is weather prediction that is very crucial in planning of day-to-day events affecting human life in many ways. Knowledge of weather parameters is also important for controlling the agricultural production. For example, adequate amount of rainfall at the time of sowing and favourable temperature and moisture conditions during different phases of crop growth is very important for healthy crop production. With increased focus on the monitoring and forecasting of rapidly evolving weather processes the need for improved temporal and spatial observations has become more critical.

After realising its potential for meteorological applications, ISRO initiated work on the dedicated satellites for meteorological applications during last decade. ISRO launched its first exclusive meteorological satellite, Kalpana-1, on September 12, 2002. Kalpana-1 has a Very High Resolution Radiometer (VHRR) with three channels providing weather parameters like Atmospheric Motion Vectors (AMV), Rainfall estimates, Upper Tropospheric Humidity, Outgoing Longwave Radiation, Sea Surface Temperature (SST) and various other agromet parameters. The half-hourly image sequences are used for the monitoring of important weather events like heavy rainfall, onset of monsoon, tropical cyclone, and numerical weather prediction.



Images from INSAT-3DR Imager channel (left, centre) and MWIR-1 Sounder channel (right)

Historically, such weather information was obtained through a network of ground observatories established by meteorological establishments, such as India Meteorology Department (IMD). However, this information was limited to a few selected cities. A satellite provides continuous observations over an entire viewing region including ocean, desert, mountains, etc,. that were difficult for the ground network.

India realised the importance of satellites for land-atmosphere-ocean observations and it has become a major thrust area for the Indian Space Programme (ISP). In this direction the INSAT series of multi-purpose geostationary satellites, conceived in the early eighties, became pivotal to meet the operational needs of weather services in the country.

Kalpana-1 was followed by a quantum jump in the observational capability of ISP with the launch of INSAT-3D in July 2013. INSAT-3D satellite with a 19-channel Sounder and a 6-channel advanced Imager is helping in the identification of the sporadic natural hazards like flash floods, cyclones, wildfire, fog, upper air turbulence, thunderstorm, etc.

INSAT-3D was followed by the INSAT-3DR that was launched by GSLV-F05 into a geostationary transfer orbit on September 08, 2016. INSAT-3DR is identical to INSAT-3D in configuration. The atmospheric vertical profiles of temperature and humidity from INSAT-3D/3DR Sounders have added a new dimension in the observational capability for monitoring and predicting the rapidly developing weather systems. Sounder instruments provide 3-dimensional thermodynamic structure of the atmosphere over Indian landmass allowing the forecasters to identify the areas of possible severe weather conditions such as thunderstorm well in advance.

The combination of INSAT-3D and INSAT-3DR provide the multi-spectral images of the earth and the atmosphere at every 15-minute interval from Imager and 30-minute interval from the Sounder that ensures more accurate and timely detection of weather parameters around the Indian subcontinent.

INSAT-3D/3DR Imagers have split-window thermal infrared channels for accurate estimation of Sea Surface Temperature (SST). Addition of a new 3.9 micron channel helps in improved SST estimation besides helping in locating the forest-fire events and also in identifying the fog covered areas. Shortwave infrared band at 1.4 micron helps in the identification of the snow cover, and the phase of water in the clouds. The visible channel along with other Imager channels provides the cloud information. The improved spatial and temporal resolutions in INSAT-3D/3DR Imagers have paved way for more accurate estimates of AMV winds that results in improved weather prediction. The Upper tropospheric humidity and Outgoing Longwave Radiation are helping in monitoring the deep convection. These parameters are also important indicators of climate change. Rainfall estimates generated at 15-minute interval are important for agriculture. INSAT-3D/3DR Imagery with enhanced spatial and temporal resolutions also provide an excellent insight into the patterns of cyclonic activity over India, helping in the improved cyclone track prediction and intensity estimation.

During clear-sky conditions, the INSAT-3D/3DR imageries help in capturing different land cover types such as cropland, forest, desert, grassland, wetlands, inland water bodies, snow-glacier, etc, in optical and thermal bands. Atmospheric haze due to dust aerosols and transport of dust can also be identified from Imager optical band.

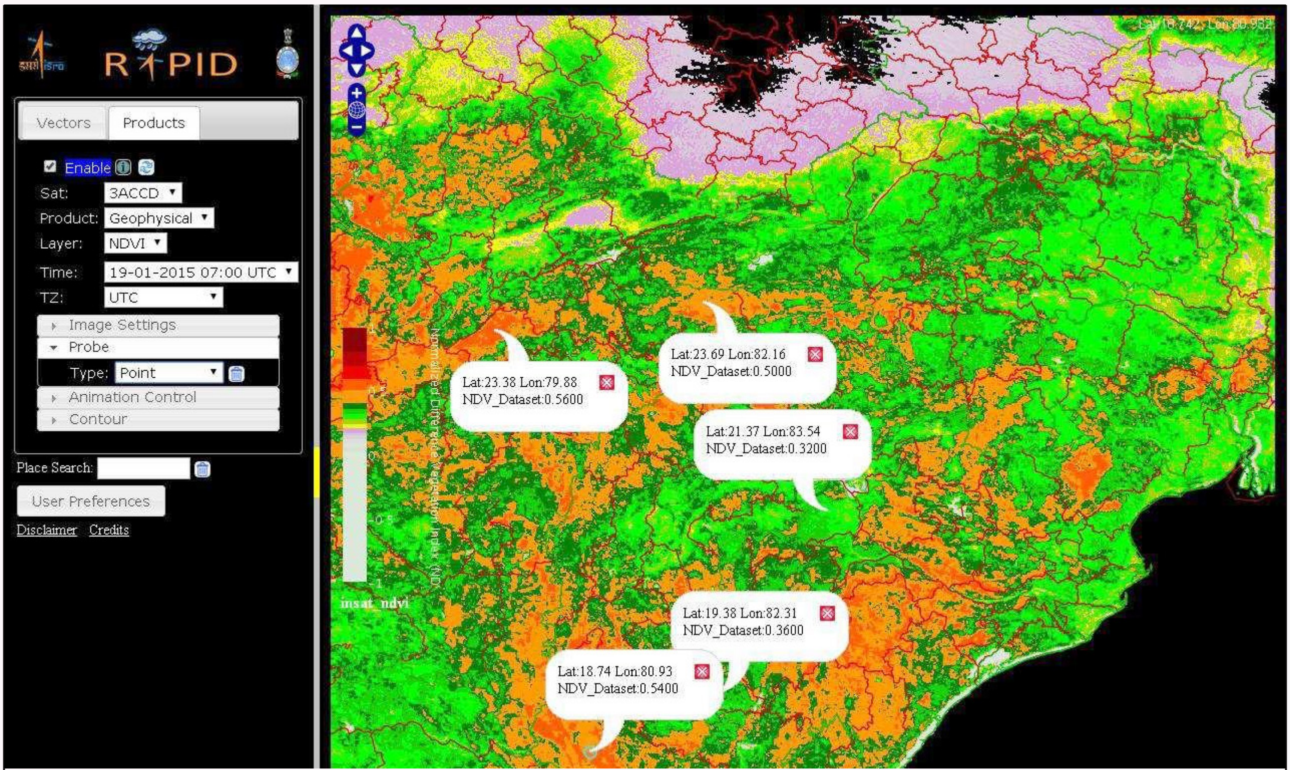
All these geo-physical data products of INSAT-3D/3DR are disseminated through Metrological and Oceanographic Satellite Data Archival Centre (MOSDAC) for in-house R&D work and other users.

RAPID: Gateway to Indian Weather Satellite Data

The INSAT series of satellites carrying Very High Resolution Radiometer (VHRR) have been providing data for generating cloud motion vectors, cloud top temperature, water vapour content, etc., facilitating rainfall estimation, weather forecasting, genesis of cyclones and their track prediction. These satellites have also carried Data Relay Transponders (DRT) to facilitate reception and dissemination of meteorological data from in-situ instruments located across vast and inaccessible areas. Kalpana-1, INSAT-3A, INSAT-3D and INSAT-3DR satellites in the geosynchronous orbit are providing meteorological data. Quick visualisation and analysis of data and products enable accurate weather assessments. Towards this, Space Applications Centre (SAC), ISRO, Ahmedabad has developed a weather data explorer application - Real Time Analysis of Products and Information Dissemination (RAPID) which is hosted in India Meteorological Department (IMD) website. This software acts as a gateway to Indian Weather Satellite Data providing quick interactive visualisation and 4-Dimensional analysis capabilities to various users like application scientists, forecasters, and the common man.

This innovative application introduces the concept of next generation weather data access and advanced visualisation capabilities. It provides access to the previous 7-day satellite data including images and geophysical parameters from Indian Satellites in near real time. More than 150 Products from Indian Weather Satellites are being hosted using this application. The scientific products which affect our daily lives like Fog, Rainfall, Snow, Temperature, etc., retrieved from INSAT-3D and Kalpana-1 are made available for the common man. It also provides animation of images based on start/end time. This feature is very useful in visualising the movement of severe weather events like cyclones.

This tool integrates the ISRO's Geo-portal Bhuvan Map Layer enabling the user to get zoomed view of a city. 'Place Search' allows the user to search, based on place name or latitude/longitude. The administrative boundaries have been integrated to provide zoomed view upto district level. The Indian Sub-basins boundaries and Flood Meteorological Office (FMO) basins provide a view of basins and sub-basins.



NDVI Point Probes with District Boundary Overlay in Red Color

This web application provides many analysis features that are of interest to the scientific community. These features include Point Probe, Time Series, Vertical Profile and Transect, Box Statistics, Distance and Area Plots. It also provides simple image processing features like Contrast Stretch, Transparency, Red Green Blue (RGB) composites from multiple layers and colour table applications. Colour tables and RGB composites help in enhancing severe weather events like cyclones, fog, cloud conditions, rainfall, etc. RAPID also provides access to temperature and humidity vertical profiles of the atmosphere at various pressure levels retrieved from INSAT-3D Sounder, the only Geostationary Sounder over the Indian Region.

In addition to the satellite data, RAPID provides support for overlaying the ground observation data from Automatic Weather Stations (AWS) of ISRO and Global Telecommunication System (GTS). These AWS measure the parameters like Temperature, Rainfall, Sunshine, Wind Direction/ Speed and Humidity. Option is also provided to synchronise ground observation with satellite data.

The latest addition to RAPID is 'Nowcast Data', which provides the forecast for next 3 hours prediction of the convective cells development and possible areas of thunderstorm.

As per the recent directive from the Government of India on the effective use of space technology by user ministries, more than 20 ministry portals were unveiled and were discussed during the National Meet on the use of space technologies, chaired by Hon'ble Prime minister of India. RAPID has become a popular platform that hosts data from Indian Geostationary Meteorological Satellite Missions in Geo-graphical Information System (GIS) environment in the country.

RAPID is also acting as a hub for satellite data and scientific products. They are effectively used for scientific studies and help students, researchers and organisations to understand the atmospheric phenomenon. During the second day of India-South Africa Cricket Test Match at Bengaluru, (November14-18, 2015), RAPID received a whopping 4000 hits as there was a large cloud cover over Southern India. There was a special mention by cricket commentators about RAPID for the latest weather conditions.

A special session towards the effective utilisation of weather data using RAPID was carried out at latest SPIE Conference held at Delhi during April 4-7, 2016. RAPID was presented and received special appreciation by Global Community in CGMS-44 Conference hosted by EUMETSAT at Biot, France during June 5-10, 2016. RAPID has become a widely popular site among all the age groups and nearly 3 lakh hits have been received since August 2015.

ISRO's Scramjet Engine Technology Demonstrator Successfully Flight Tested

Today, satellites are launched into orbit by multi-staged satellite launch vehicles that can be used only once (expendable). These launch vehicles carry oxidiser along with the fuel for combustion to produce thrust. Launch vehicles designed for one time use are expensive and their efficiency is low because they can carry only 2-4% of their lift-off mass to orbit. Thus, there is a worldwide effort to reduce the launch cost.

Nearly 70% of the propellant (fuel-oxidiser combination) carried by launch vehicles consists of oxidiser. Therefore, the next generation launch vehicles must use a propulsion system which can utilise the atmospheric oxygen during their flight through the atmosphere which will considerably reduce the total propellant required to place a satellite in orbit.

Also, if those vehicles are made re-usable, the cost of launching satellites will further come down significantly. Thus, the future re-usable launch vehicle concept along with air-breathing propulsion is an interesting candidate offering routine access to space at far lower cost.

Considering the strategic nature of air-breathing technology which has the potential to bring a significant shift in the launch vehicle design, worldwide efforts are on to develop the technology for air breathing engines. Ramjet, Scramjet and Dual Mode Ramjet (DMRJ) are the three concepts of air-breathing engines which are being developed by various space agencies.

A Ramjet is a form of air-breathing jet engine that uses the vehicle's forward motion to compress incoming air for combustion without a rotating compressor. Fuel is injected in the combustion chamber where it mixes with the hot compressed air and ignites. A ramjet-powered vehicle requires an assisted take-off like a rocket assist to accelerate it to a speed where it begins to produce thrust.

Ramjets work most efficiently at supersonic speeds around Mach 3 (three times the speed of sound) and can operate up to speeds of Mach 6. However, the ramjet efficiency starts to drop when the vehicle reaches hypersonic speeds.

A Scramjet engine is an improvement over the ramjet engine as it efficiently operates at hypersonic speeds and allows supersonic combustion. Thus it is known as Supersonic Combustion Ramjet, or Scramjet.

A Dual Mode Ramjet (DMRJ) is a type of jet engine where a ramjet transforms into Scramjet over Mach 4-8 range, which means it can efficiently operate both in subsonic and supersonic combustor modes.

An important development in ISRO's Air Breathing Propulsion Project (ABPP) occurred on August 28, 2016, which was the successful flight testing of its Scramjet.

Scramjet Engine –TD

This first experimental mission of ISRO's Scramjet Engine towards the realisation of an Air Breathing Propulsion System was successfully conducted from Satish Dhawan Space Centre SHAR, Sriharikota.

After a smooth countdown of 12 hours, the solid rocket booster carrying the Scramjet Engines lifted off at 0600 hrs (6:00 am) IST. The important flight events, namely, burn out of booster rocket stage, ignition of second stage solid rocket, functioning of Scramjet engines for 5 seconds followed by burn out of the second stage took place exactly as planned.

After a flight of about 300 seconds, the vehicle touched down in the Bay of Bengal, approximately 320 km from Sriharikota. The vehicle was successfully tracked during its flight from the ground stations at Sriharikota.

With this flight, critical technologies such as ignition of air breathing engines at supersonic speed, holding the flame at supersonic speed, air intake mechanism and fuel injection systems have been successfully demonstrated. The Scramjet engine designed by ISRO uses Hydrogen as fuel and the Oxygen from the atmospheric air as the oxidiser. The August 28 test was the maiden short duration experimental test of ISRO's Scramjet engine with a hypersonic flight at Mach 6. ISRO's Advanced Technology Vehicle (ATV), which is an advanced sounding rocket, was the solid rocket booster used for this recent test of Scramjet engines at supersonic conditions. ATV carrying Scramjet engines weighed 3277 kg at lift-off.

ATV is a two-stage spin stabilised launcher with identical solid motors (based on Rohini RH560 sounding rocket) as the first as well as the second stage (booster and sustainer). The twin Scramjet engines were mounted on the back of the second stage. Once the second stage reached the desired conditions for engine "Start-up", necessary actions were initiated to ignite the Scramjet engines and they functioned for about 5 seconds. ATV flight operations were based on a pre-programmed sequence.

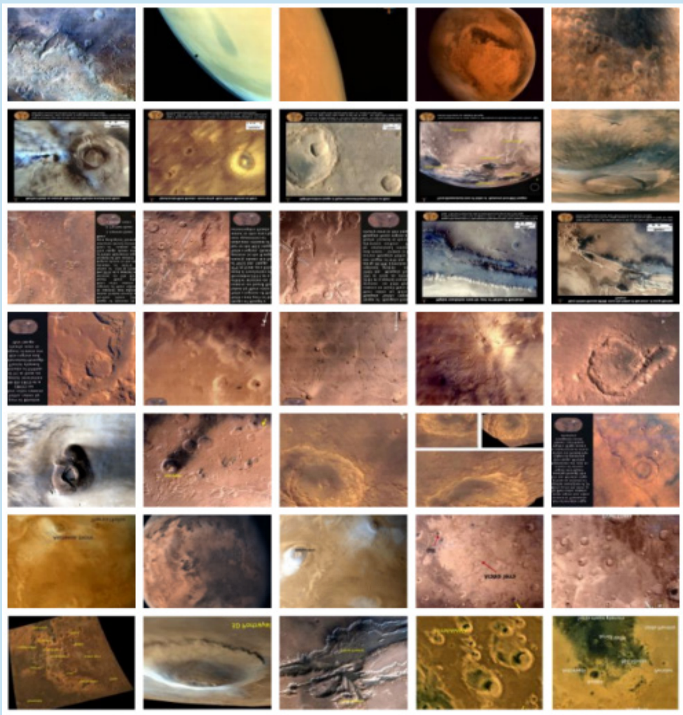
Some of the technological challenges handled by ISRO during the development of Scramjet engine include the design and development of Hypersonic engine

air intake, the supersonic combustor, development of materials withstanding very high temperatures, computational tools to simulate hypersonic flow, ensuring performance and operability of the engine across a wide range of flight speeds, proper thermal management and ground testing of the engines.

India is the fourth country to demonstrate the flight testing of a Scramjet Engine.

First year data of Mars Orbiter Mission (MOM) released

On the occasion of two year completion of Mars Orbiter Mission, ISRO released the first year of MOM Long-term archive data (September 2014 to September 2015) to the public on September 23, 2016 through website. 1,100 users registered till December 2016 and downloaded about 200 Gb data.



ISRO Enables Telemedicine Service Enroute Amarnath

The Telemedicine Programme of ISRO is an innovative process of synergising benefits of Satellite communication technology and information technology with Biomedical Engineering and Medical Sciences to deliver the health care services to the remote, distant and underserved regions of the country. ISRO telemedicine facility connects the remote District Hospitals/Health Centres with Super Specialty Hospitals in the cities, through INSAT Satellites for providing expert consultation.

Considering the shortage of doctors in remote, inaccessible and rural areas of the country, the Development and Educational Communication Unit (DECU) of ISRO and Ministry of Health & Family Welfare (MoH&FW), Govt. of India signed a Memorandum of Understanding (MoU) to work jointly towards effective utilisation of ISRO's satellite based Telemedicine network.

Bringing this noble idea to fruition and in an effort to deliver best healthcare services to residents and lakhs of pilgrims who pass through remote areas near the Holy Amarnath caves, ISRO, MoH&FW and J&K Ministry of Health joined hands to set-up a Satellite based Telemedicine facility at Sheshnag area, located at an elevation of around 13,000 feet in the Kashmir valley.

By July 2016 end, a team consisting of the senior officials from DECU/ISRO (Ahmedabad) and Directorate of Health Services (Srinagar) steadfastly carried out the work to set-up the Telemedicine node at Sheshnag base camp enroute to Amarnath Shrine under extreme weather conditions, difficult terrains and other unexpected challenges.

The Sheshnag telemedicine node consists of a Very Small Aperture Terminal (VSAT) System, videoconferencing equipment, telemedicine software along with medical diagnostic instruments like ECG machine and X-Ray scanner.

The tele-consultation for this node is in the field of General Medicine, Orthopaedics, Respiratory and Cardiology disciplines planned through PGIMER (Chandigarh), SKIIMS (Srinagar), AIIMS (Bhopal), JIPMER (Puducherry). However, the tele-consultation can be obtained from any of the super-specialty nodes set-up across the country.

ISRO and Ministry of Health have set on a new course for healthcare in India by reaching out to the countrymen, who need it the most, in the remote regions of the country. The Telemedicine centres not only double up as first aid centres, but also provide the best consultation facilities in the remote regions, through specialty hospitals located across the country.

The officials of Health Ministry, Shrine board, local Administration, Indian Air Force, local Police, Army, Border Security Force and Central Reserve Police Force, all worked hand-in-hand, strongly supported and were part of this successful valiant effort.

This work is a shining example of excellent teamwork between diverse agencies of Central and State Government, which will be a trendsetter for the future. The credit goes to every individual of agencies, which participated, in this noble work in different capacities.

Tele-consultation from PGIMER, Chandigarh to Sheshnag, Jammu & Kashmir

Telemedicine node with videoconferencing and medical diagnostic instruments

Antarctica Ground Station for Earth Observation Satellites (AGEOS)

ISRO has established the Antarctica Ground Station for Earth Observation Satellites (AGEOS), at Bharati Station, Larsemann Hills, Antarctica, for receiving Indian Remote sensing Satellite (IRS) data. This state-of-the-art advanced Ground station was commissioned during August 2013 and is receiving data from IRS satellites (like Resourcesat-2, RISAT-1, Cartosat-1) and transferring the same to NRSC, Shadnagar near Hyderabad. This extended data receive antenna system of Antarctica supplements Earth Observation (EO) data collection for ISRO. An Earth Station at Polar region has the advantage of visibility of 10 passes per day for each mission. This would provide global remote sensing data acquisition capability.

Atmospheric CO_2 Sensor at Bharati Station NRSC

The remote sensing data recorded on the Solid State Recorder (SSR) onboard IRS Satellites are dumped at the AGEOS when the satellite passes over it and the SSR will be ready for recording data during the next pass. The data dumped at AGEOS is being transferred to NRSC, Shadnagar through a link established using a Communication Satellite.

In this regard, earlier a 3 m C-Band Earth station was also installed and commissioned at Maitri (71deg S, 11 deg E), Antarctica to provide a two-way Communication Link between Maitri, Antarctica and mainland India. At the time of installation and commissioning, this Earth station was characterised and tested using a 13 m antenna system at Master Control Facility (MCF), Hassan. Later on, a 7.2 m C- Band station was also installed and commissioned at the National Centre for Antarctica & Ocean Research (NCAOR), Goa to establish a dedicated communication link for round the clock operation. This was designed to operate at a very low elevation angle for the video conferencing, video streaming and internet browsing applications. The link operates at a data rate of around one Mbps between Maitri and NCAOR. This Satcom station is providing the vital communication support to the Indian scientific community for pursuing their research work at Maitri throughout the year. With the commissioning of the Earth station at NCAOR, Goa, the Indian station, Maitri has been brought in the ambit of World Wide Web.

The AGEOS station at Bharati, (69deg S and 76deg E) receives payload data from IRS Satellite Missions in S/X-Band daily. A communication satellite link between Bharati and two stations in India (NRSC, Shadnagar and NCAOR, Goa) has been established with a bandwidth of 40 Mbps, which transfers about 100 GB/day Payload data dumped at Antarctica Station to NRSC, Shadnagar. Further Ancillary processing of all the acquired data at AGEOS is carried out at NRSC, Shadnagar, from wherein the pre-processed products are made available in a common Storage Area Network (SAN) for further processing. Apart from this, AGEOS plays a crucial role in carrying out Uplink of Tele commands to current Indian Remote sensing Missions namely, RISAT-1, Resourcesat-2, Cartosat-1, Cartosat-2, Cartosat-2A, Cartosat-2B, SARAL-1 and Oceansat-2, and the recently launched Cartosat-2 series satellite.

Measurement of Total Ozone during Ship Voyage

The AGEOS is continuously operated and maintained by the Engineers of ISRO who are under deputation to Bharati Station, Antarctica on a regular basis.

ISRO's Participation in Antarctic Expedition

The National Centre for Antarctic and Ocean Research (NCAOR), Ministry of Earth Sciences, Government of India, organises the Indian Scientific Mission to Antarctica every year and ISRO has been participating in it for a long time. This year, in the 35th Indian scientific expedition, ISRO participated with three projects - one on-going project from Space Application Centre (SAC) and two new projects from National Remote Sensing Centre (NRSC).

GPR Observations over Sea Ice

During the expedition, the project team collected ground data to interpret and validate the satellite images and also installed instruments for the measurement of greenhouse gases and atmospheric black carbon during Austral summer (November 2015 - March 2016). Snow properties were observed using Ground Penetrating Radar (GPR) to understand melt/freeze dynamics and its response to microwave remote sensing data and snow fork (density and wetness) near Bharati and Maitri Indian stations. GPR Profiles were collected on sea ice and on ice sheet to measure the thickness.

Spatio-temporal dynamics of surface melting over Antarctica using scatterometer data from OSCAT on-board Oceansat-2 and QuikSCAT are made available under NICES programme on Bhuvan Portal

Prof. U R Rao inducted into the 2016 IAF Hall of Fame

Prof. U R Rao, former Chairman, ISRO and Secretary, Department of Space, was inducted into the prestigious "The 2016 IAF Hall of Fame" by the International Astronautical Federation (IAF) during the closing ceremony of the International Astronautical Congress 2016 held at Guadlajara, Mexico on September 30, 2016 attended by distinguished guests consisting of Space Scientists, Industry Leaders, Administrators and Professionals.

Prof. Rao's citation read out at the time of induction is as follows: “Prof. U.R. Rao is hereby inducted into THE 2016 IAF HALL OF FAME for his outstanding contributions to the development of space technology in India and for his relentless efforts towards sharing the greater benefits of space technology with developing countries and the world at large ……”.

Prof. U R Rao, Chairman, Governing Council of the Physical Research Laboratory, Ahmedabad, is an internationally renowned space scientist who has contributed to the development of space technology in India and its extensive application to communications and remote sensing of natural resources since starting his career in 1960. Prof. Rao is responsible for the creation of India's space and satellite capabilities and their application to the nation's development.

Prof. Rao undertook the responsibility for the establishment of satellite technology in India in 1972. Under his guidance, beginning with the first Indian satellite 'Aryabhata' in 1975, over 20 satellites were designed, fabricated and launched. Prof. Rao also accelerated the development of rocket technology in India, resulting in the successful launch of ASLV rocket in 1992 and the operational PSLV launch vehicle. He has tirelessly promoted the use of space technology for broadcasting, education, meteorology, remote sensing and disaster warning. Prof. Rao, who has published over 360 scientific and technical papers in various journals, has received many honours and awards, including the Padma Bhushan Award, a very prominent civilian award of the Government of India. Earlier in 2013, Prof.U R Rao was inducted into the Satellite Hall of Fame, Washington by the "Society of Satellite Professionals International".

Journey of ISRO From "Aryabhata Mission" to "Mars Orbiter Mission"

The Fully Integrated GSLV-F05 Carrying INSAT-3DR Approaching the Second Launch Pad

इसरो isro

Antariksh Bhavan, New BEL Road, Bengaluru - 560 231, India.
www.isro.gov.in