अन्तरिक्ष भारत
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भारतीय अन्तरिक्ष अनुसंधान संगठन

Indian Space Research Organisation

जनवरी-जून 2017   January-June 2017

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.

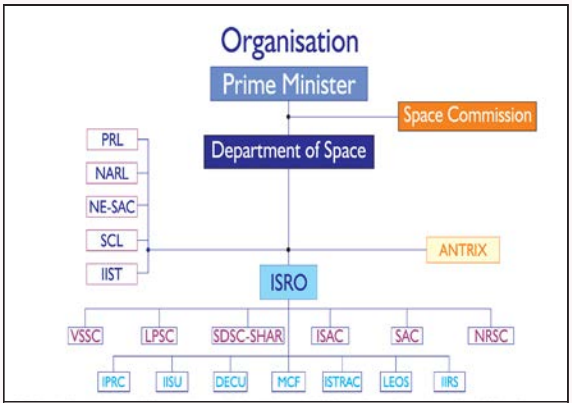
Department of Space has the primary responsibility of promoting the development of space science, technology and applications towards achieving self reliance and assisting in all round development of the nation. Towards this, DOS has evolved the following programmes:

- 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, 91 Indian Satellite Missions, nine Students Satellites, two Re-entry Missions – SRE-1 and CARE module and 63 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

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Contents

Editors

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India's GSAT-17 Communication Satellite Launched Successfully

India's latest communication satellite, GSAT-17 was inducted into the INSAT/GSAT system on June 29, 2017 from Kourou, French Guiana by Ariane-5 VA-238. Weighing 3477 kg at lift-off, GSAT-17 carries Payloads in Normal C-band, Extended C-band and S-band to provide various communication services. GSAT-17 also carries equipment for metereological data relay and satellite based search and rescue services being provided by earlier INSAT satellites. GSAT-17 became India's third communication satellite to successfully reach orbit in the past two months.

GSAT-17 Undergoing Vibration Test

GSAT-17 is designed to provide continuity of services on operational satellites in C-band, Extended C-band and S-bands. After its lift-off at 0245 hrs (2:45 am) IST and a flight lasting about 39 minutes, GSAT-17 separated from the Ariane 5 upper stage in an elliptical Geosynchronous Transfer Orbit (GTO) with a perigee (nearest point to Earth) of 249 km and an apogee (farthest point to Earth) of 35,920 km, inclined at an angle of 3 degrees to the equator.

ISRO's Master Control Facility (MCF) at Hassan in Karnataka took over the command and control of GSAT-17 immediately after its separation from the launch vehicle. Preliminary health checks of the satellite revealed its normal functioning.

Subsequently, the orbit raising manoeuvres were performed to place GSAT-17 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-17 were deployed. Following this, the satellite was put in its final orbital configuration. GSAT-17 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-17 were turned on. After the successful completion of all the in-orbit tests, GSAT-17 was made ready for operational use.

The designed in-orbit operational life of GSAT-17 is about 15 years.

Services	Communication, Meteorological data relay and satellite based search and rescue
Orbit	Geostationary
Mission Life	About 15 years
Life-off Mass	3477 kg
Dry mass	1480 kg
Spacecraft Control	3 Axis body Stabilised
Propulsion	Bi-propellant system
Power	6200 W from solar arrays, Two 144 Ah Li-Ion batteries

Salient Features of GSAT-17

PSLV-C38 Successfully Launches 31 Satellites in a Single Flight

ISRO's Polar Satellite Launch Vehicle PSLV-C38 successfully launched the 712 kg Cartosat-2 Series Satellite along with 30 co-passenger satellites on June 23, 2017 from Satish Dhawan Space Centre SHAR, Sriharikota. This is the thirty ninth consecutively successful mission of PSLV.

PSLV-C38 lifted off at 0929 hrs (9:29 am) IST, as planned, from the First Launch Pad. After a flight of about 16 minutes, the satellites achieved a polar Sun Synchronous Orbit of 505 km inclined at an angle of 97.44 degree to the equator (very close to the intended orbit) and in the succeeding seven and a half minutes, all the 31 satellites successfully separated from the PSLV in a predetermined sequence beginning with Cartosat-2 series satellite, followed by NIUSAT and 29 customer satellites. The total number of Indian satellites launched by PSLV now stands at 48.

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. In the following days, the satellite was brought to its final operational configuration following which it started providing various remote sensing services using its panchromatic (black and white) and multispectral (colour) cameras.

One of the 30 co-passenger satellites carried by PSLV-C38 was the 15 kg NIUSAT, a University/ Academic Institute satellite from Noorul Islam University, Tamil Nadu, India. The remaining 29 co-passenger satellites carried were international customer satellites from USA (10), United Kingdom (3), Belgium (3), Italy (3), Austria (1), Chile (1), Czech Republic (1), Finland (1), France (1), Germany (1), Japan (1), Latvia (1), Lithuania (1) and Slovakia (1).

With this successful launch, the total number of customer satellites from abroad placed in orbit by India's workhorse launch vehicle PSLV has reached 209.

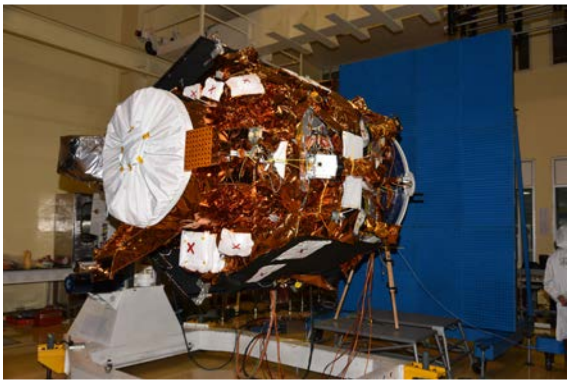
PSLV-C38 at a Glance

	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PSI 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Composite solid	Earth Storable Liquid	Composite solid	Earth Storable Liquid
Propellant Mass (T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.3
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

Panoramic view of fully integrated PSLV-C38 seen with Mobile Service Tower

Cartosat-2 Series Satellite

Cartosat-2 Series Satellite is the primary satellite carried by PSLV-C38. This remote sensing satellite is similar in configuration to earlier satellites in the series with the objective of providing high-resolution scene specific spot imagery.



Cartosat-2 Series Satellite undergoing EMI Radiation Test

The imagery sent by 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, change detection to bring out geographical and manmade features and various other Land Information System (LIS) as well as Geographical Information System (GIS) applications.

Indian University Satellite - NIUSAT

NIUSAT is an Indian University/Academic Institute satellite from Noorul Isalm University, Tamil Nadu, launched by PSLV-C38. This 15 kg three axis stabilised satellite is built to provide multispectral imagery for agricultural crop monitoring and disaster management support applications.

NIUSAT in Clean Room

A dedicated Mission Control Centre with UHF/VHF antenna for Telemetry/Tele-command operations and S-band antenna for Payload data reception has been established at the university.

Multi-spectral Image of Doha, Qatar taken on June 26, 2017

Mars Orbiter Mission Completes 1000 Days in Orbit

Mars Orbiter Mission (MOM), the maiden interplanetary mission of ISRO, launched on November 5, 2013 by PSLV-C25 got inserted into Martian orbit on September 24, 2014 in its first attempt. MOM completes 1000 Earth days in its orbit, today (June 19, 2017) well beyond its designed mission life of six months. 1000 Earth days corresponds to 973.24 Mars Sols (Martian Solar day) and MOM completed 388 orbits.

MOM is credited with many laurels like cost-effectiveness, short period of realisation, economical mass-budget, miniaturisation of five heterogeneous science payloads etc. Satellite is in good health and continues to work as expected. Scientific analysis of the data received from the Mars Orbiter spacecraft is in progress.

ISRO has also launched MOM Announcement of Opportunity (AO) programmes for researchers in the country to use MOM data for R&D. The success of Mars Orbiter Mission has motivated India's student and research community in a big way. Thirty-two proposals were supported under this AO. A Planetary data analysis workshop was also conducted to strengthen the MOM-AO scientist's research interest.

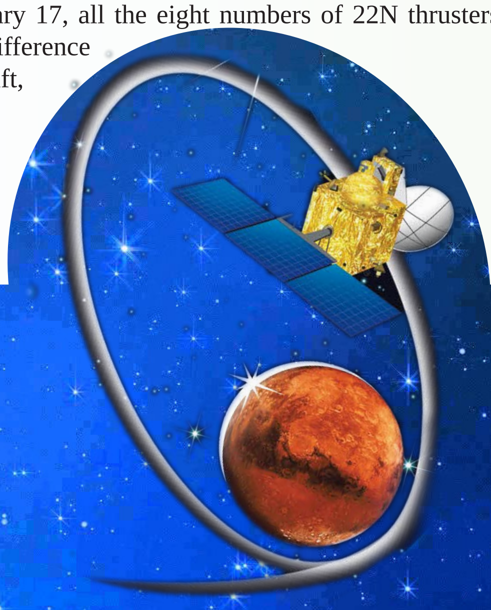
First year data from MOM was released to public on September 24, 2016 through ISSDC website. There are 1381 registered users and 370 GB data has been downloaded.

The Mars Colour Camera, one of the scientific payloads onboard MOM, has produced more than 715 images so far. Mars Atlas was prepared and made available on ISRO website.

MOM went through a communication 'blackout' as a result of solar conjunction from June 2, 2015 to July 2, 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.

MOM spacecraft experienced the 'whiteout' geometry during May 18 to May 30, 2016. 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 satellite in the 'whiteout' period. Payload operations were suspended. Fault Detection, Isolation and Recovery 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 loss of attitude. The spacecraft came out of 'whiteout' geometry successfully on May 30, 2016 and has been normalised for regular operations.

An orbital manoeuvre was performed on MOM spacecraft to avoid the impending long eclipse duration for the satellite. The duration of the eclipse would have been as long as 8 hours. As the satellite battery is designed to handle eclipse duration of only about 1 Hour 40 minutes, a longer eclipse would have drained the battery beyond the safe limit. The manoeuvres performed on January 17, 2017 brought down the eclipse duration to zero during this long eclipse period. On the Evening of January 17, all the eight numbers of 22N thrusters were fired for a duration of 431 seconds, achieving a velocity difference of 97.5 m/s. This has resulted in a new orbit for the MOM spacecraft, which completely avoided eclipse up to September 2017. About 20 kg propellant was consumed for this manoeuvres leaving another 13 kg of propellant for its further mission life.



First Developmental Flight of India's GSLV-Mk III Successfully Launches GSAT-19 Satellite

The first developmental flight (GSLV-Mk III) of India's heavy lift launch vehicle GSLV-Mk III was successfully conducted on June 05, 2017 evening from Satish Dhawan Space Centre SHAR, Sriharikota with the launch of GSAT-19 satellite. This was the first orbital mission of GSLV-Mk III which was mainly intended to evaluate the vehicle performance including that of its fully indigenous cryogenic upper stage during the flight.

After a twenty five and a half hour smooth countdown, the mission began with the launch of the 640 ton GSLV-Mk III at 5:28 pm IST from the Second Launch Pad as scheduled with the ignition of its two S200 solid strap-on boosters. Following this, the major phases of the flight occurred as scheduled. The upper stage of GSLV-Mk III vehicle is a new cryogenic stage (C25) indigenously configured, designed and realised by ISRO. The cryogenic stage used liquid Hydrogen and liquid Oxygen as propellants with a total loading of 28 tons. The stage is powered by a 20 ton thrust cryogenic engine (CE20) operating on 'gas generator cycle'. The performance of the engine and stage during the mission was as predicted. About sixteen minutes after lift-off, GSAT-19 satellite was successfully placed in orbit.

Soon after its separation from GSLV, the Master Control Facility (MCF) at Hassan in Karnataka assumed control of the satellite. GSAT-19 is a high throughput communication satellite.

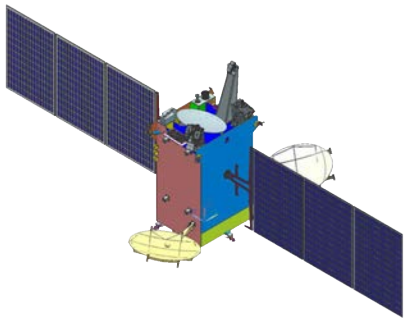
Orbit of GSAT-19 was raised from its Geosynchronous Transfer Orbit (GTO) to the final circular Geostationary Orbit (GSO) by firing the satellite's Liquid Apogee Motor (LAM) in stages. Subsequently, the solar panels and antenna reflectors of the satellite were deployed and satellite was commissioned into service after positioning in the designated slot following in-orbit testing of its payloads.

Parameters	Stages		
	Two S 200	**L110**	**C25**
Length (m)	26.2	21.39	13.545
Diameter (m)	3.2	4	4
Propellants	Composite solid	Hypergolic liquid	Cryogenic
Propellant Mass (t)	2 x 205	116	28
Stage Mass at Lift-off (t)	472	125	33

GSLV-Mk-III-D1 Stage Characteristics

GSAT-19

GSAT-19 is a Geostationary Communication satellite of India, configured around the ISRO's standard I-3K bus. Weighing 3136 kg at lift-off, GSAT-19 is the heaviest satellite launched from the Indian soil. The main structure of the satellite is cuboid in shape built around a Carbon Fiber Reinforced Polymer (CFRP) central cylinder.



GSAT-19 Satellite

The two solar arrays of GSAT-19 consisting of Ultra Triple Junction solar cells generate about 4500 Watts of electrical power. Sun, Earth and Star sensors as well as gyroscopes provide orientation reference for the satellite. The Attitude and Orbit Control System (AOCS) of GSAT-19 maintains the satellite's orientation with the help of momentum wheels, magnetic torquers and thrusters. The satellite's propulsion system consists of a Liquid Apogee Motor (LAM) and chemical thrusters using liquid propellants for initial orbit raising and station keeping. GSAT-19 carries Ka/Ku-band high throughput communication transponders. Besides, it carries a Geostationary Radiation Spectrometer (GRASP) payload to monitor and study the nature of charged particles and the influence of space radiation on satellites and their electronic components. GSAT-19 also features certain advanced spacecraft technologies including miniaturised heat pipe, fibre optic gyro, Micro Electro-Mechanical Systems (MEMS) accelerometer, Ku-band TTC transponder, as well an indigenous Lithium-ion Battery.

After its separation from the GSLV MkIII in GTO, GSAT-19 will use its own propulsion system to reach its geostationary orbital home.

The First Developmental Flight of GSLV-Mk III

With the successful first developmental flight - GSLV-Mk III-D1, carrying the high through put satellite GSAT-19, India has achieved self-reliance in launching 4 ton class satellite to Geosynchronous Transfer Orbit (GTO).

With the current fleet of operational launch vehicles namely PSLV and GSLV, India can meet the requirements of launching communication satellites up to 2.2 tons to GTO. With the introduction of GSLV-Mk III, the payload capability has been doubled which will meet the national requirement of launching communication satellites.

GSLV-Mk III is a three stage vehicle designed for catering the need of carrying heavier communication satellite to GTO. The vehicle lift off mass is 640 ton with overall height of 43.498 m and core diameter of 4 m. The vehicle has two Solid Strap-on motors - S200, a core liquid booster stage - L110, and a cryogenic upper stage - C25. To accommodate heavier payloads, 5 m diameter Ogive Payload Fairing is employed.

S200 strap on motor is a 3.2 m diameter solid motor. It is made up of 3 motor segments and has a flex nozzle control system. To reduce the disturbance moment due to differential thrust between the two S200 strap on motors in flight, the two motors are processed as a pair during the motor segments casting. L110 liquid Stage, works on two clustered Vikas engines which are being used in PSLV & GSLV. It has 110 tons of propellant loading and each of the twin engines produces 80 tons of thrust. The upper stage in GSLV-MK III vehicle is cryogenic stage with 28 tonnes of propellant loading and designated as C25. The C25 Stage is powered with a 20 ton thrust (nominal) engine working on Gas Generator (GG) cycle. C25 stage is a high performance cryo stage carrying a propellant combination of liquid Hydrogen stored at 20 K and liquid Oxygen stored at 77 K. C25 Engine & stage were developed and validated through a series of 200 tests which included qualification tests through a step by step process of component level test, engine level test for a duration of 800 s and stage level test for a duration of 640s equal to its flight time. This C25 Engine is entirely indigenous starting from configuration, design, development and qualification strategies. The entire test programme of integrated C25 Engine & stage were done in fast track mode and completed in a short time frame of two years using limited number of hardware and optimal sequencing of tests. During the maiden flight of GSLV-Mk III on June, 5 2017 the vehicle carried the GSAT-19 satellite onboard, weighing 3,136 kg, to the targeted GTO of 170 km by 36,000 km.

The vehicle lifted off from the launch pad upon the simultaneous ignition of both S200 motors. L110 core stage ignited during S200 thrusting phase itself at 112.66 s after lift off to augment the thrust of the vehicle and continued to function beyond the separation of two solid strap-ons which occurred at 140.84s from lift off. After nearly 206 s of firing, L110 stage separated followed by the ignition of C25 cryogenic stage. C25 stage operated for around 625 s duration and once the required orbital conditions were achieved, the cryogenic stage shut off the engine. Then the GSAT-19 satellite was injected into GTO. The performance of the two paired S200 motors were as predicted during flight and the

GSLV-Mk III-D1 at the Launch Pad

differential thrust between the motors was benign. L110 stage performed exactly as per prediction & the performance of the twin clustered Vikas engines was identical. It is to be noted that even though GSLV Mk-III D1was the second flight as far as the S200 and L110 are concerned, for the newly developed C25 stage this was the maiden flight. The performance of the C25 stage in this maiden flight was as per prediction, which establishes the capability of ISRO to predict the flight performance in advance.

The experimental flight of GSLV-Mk III (LVM3-X) was undertaken on December 18, 2014 with

S200 and L110 stages to demonstrate the atmospheric regime of the flight and unique features in GSLV-Mk III, compared to other launch vehicles, including the differential thrust between the two S200 solid strap-ons.

Based on the flight data analysis of LVM3-X mission, suitable improvements have been incorporated in GSLV-Mk III vehicle configuration, mainly on aerodynamic shaping, which included Ogive shaped Payload Fairings, Slanted Nose Cones for S200, aero shaping of cowlings & shrouds and closed Inter-Tank Structure for C25 stage. This has helped in improving the vehicle robustness, with better aerodynamic margins and reduced overall acoustic levels. Modification in S200 motor Head End Segment grain configuration was also done to reduce the dynamic pressure during flight. All these changes were qualified through ground tests as well as detailed characterisation tests and were incorporated in GSLV-MK-III- D1 vehicle.

With the successful completion of the first development flight, ISRO now gears up for the second development flight - GSLV-Mk III-D2 with augmented payload capability so that the first operational flight of GSLV-MK III will carry around 4000 kg payload to GTO. The strategies/technologies for achieving the above capabilities are identified and ISRO is working towards perfecting these technologies before implementation in the flight.

Success of the first development flight of GSLV-Mk III on June 05, 2017 is indeed a rare feat.

GSLV-MK III-D1 Lift-off

National Database for Emergency Management (NDEM) Version 3.0 Released

Government of India has envisaged a policy to build a safer and disaster resilient India by developing a holistic, integrated and proactive multi disaster and technology driven strategy for disaster management through collective efforts of all Government Agencies and Non-Government Organisations.

Ministry of Home Affairs (MHA) has translated this approach into National Database for Emergency Management (NDEM), and entrusted the responsibility of implementing NDEM to Indian Space Research Organisation (ISRO), Department of Space for reducing the impact of natural and man-made disasters and providing timely information and decision-making tools in the event of disasters. National Remote Sensing Centre (NRSC), ISRO, Hyderabad is the lead agency to implement and operationalise NDEM project.

Accordingly, NDEM Version 1.0 was operationalised in 2013. Subsequently, NDEM Version 2.0 was launched in 2015 with improved features like multi-scale databases, decision-support tools and mobile apps with secured access. In addition, value added products such as flood inundation maps, forest fire hotspots, damage assessment maps, drought indices maps etc., are hosted on NDEM Portal for all major disaster events since 2013. The portal is also equipped with multi-resolution satellite imagery ranging from 5.8m to sub-metre. Currently, NDEM services are deployed for all 36 States/UTs with multi-institutional support from Central/State Departments.

In order to enhance NDEM features and services, NDEM Version 3.0, a web enabled Geo-portal has been developed for emergency management. The objective of the portal is to serve the nation with a comprehensive multi-scale Geo-spatial database services coupled with set of decision support tools to assist the disaster managers during emergency situations.

The portal is browser independent and compatible to all computer devices and mobile phones with vector rendering services. The salient features of the NDEM Version 3.0 are:

- A dashboard for visualisation of disaster alerts, warnings issued by nodal departments, current disaster news and authorised social media content
- Incident reporting through web and mobile apps
- Integrated visualisation of multi-scale data services
- Customised decision support tools such as proximity and optimal path analysis, report generation, etc., for relief management
- Interactive tools for communication among State Government Departments and MHA through portal
- Live audio/video module for visualisation of on-site response operations
- Resource management module for allocation and monitoring of relief resources

NDEM Version 3.0 portal was released recently by Hon'ble Home Minister Shri Rajnath Singh during the inaugural ceremony of 2nd meeting of National Platform on Disaster Risk Reduction (NPDRR) at Vigyan Bhavan, New Delhi on May 15, 2017.

Launch of NDEM Version 3.0 Portal by Hon'ble Home Minister

NARL MST Radar Observations Help Resolve Ionospheric Echoing Riddle

The high power, large aperture Mesosphere-Stratosphere-Troposphere (MST) Radar established at NARL, Gadanki nearly two and half decades ago, was designed to study the middle and upper atmospheric dynamics. This radar has made a major contribution in resolving a 50-year old ionospheric echoing riddle. This riddle is linked with the radar echoes during daytime in the height region of 140-170 km in the earth's ionosphere where there is no known source of strong current/electric field and density gradient engendering the growth of plasma instability. In a significant way, the NARL MST radar observation has provided the first experimental evidence on the occurrence of the 150 km echoes outside the magnetic equator. These echoes, however, have not been observed at mid latitudes and hence their confinement to low magnetic latitudes indicates the role of near horizontal earth's magnetic field on the phenomenon. This echoing phenomenon has not only surprised the ionospheric scientists all over the world but remains as the most puzzling and challenging field in the ionospheric plasma physics today. These echoes, however, are used as a reliable means of estimating daytime ionospheric zonal electric field that drives the equatorial plasma fountain and a number of ionospheric phenomena, which are detrimental for satellite based navigation/ communication systems.

An example of these echoes observed by the NARL MST radar, presenting the height-time distribution of signal-to-noise ratio of the echoes, shows a spectacular forenoon descent and afternoon ascent of the echoing regions, indicating the direct solar zenith angle control on the echoing process, unlike any other equatorial ionospheric echoing phenomenon.

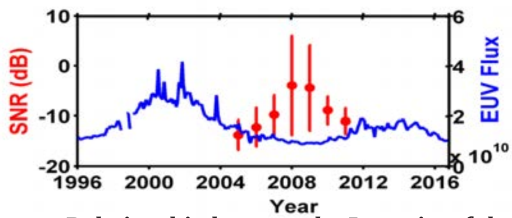
The occurrence frequency of these echoes, however, is the lowest during the equinoxes, when the Sun is over the equator, moderate in the winter, and highest in summer, which clearly presents the complex role of the solar radiation and other dynamics on the echoing phenomenon.

NARL observations have further revealed that these echoes come in two distinct types: in one type (Type-A) echoes come with low Signal-to-Noise-Ratio (SNR) (<5 dB) and spectral width is dependent on SNR, and in the other type (Type-B), echoes come with high SNR (as high as 25 dB) and spectral width is nearly independent of SNR. This finding has later been confirmed by the radar observations from Jicamarca, the most powerful equatorial radar in the world.

The latest large-scale kinetic simulation of photoelectron induced plasma waves, published in Geophysics Research Letters (2016), suggested that the puzzling echoes are possibly linked with energetic photo-electrons, which can drive Langmuir, lower and upper hybrid, and electron Bernstein waves. While this seminal work has begun a new approach to address the five decades long 150-km echoing riddle, two recent new findings made from NARL has raised shortcomings of this theoretical premise. Two important findings from NARL that enforced to modify the existing thinking are the clear connection of the type-B echoes to the unusually deep solar minimum of 2008-2009 and the inverse relationship of the puzzling echoes with the solar EUV radiation, suggesting a clear solar activity dependence of the phenomenon.

These new observational findings, illustrating the complexity and richness of physics in the peak production region of the ionosphere, have been published in the American Geophysical Union journal, Geophysical Research Letters, vol. 43, pp. 11,129-11,136 (2016). The paper has raised important questions, namely, (1) what causes the seasonal, day-to-day and the finer details of the local time variations of the 150 km echoes? and (2) what causes the 150 km echoes including the type-B echoes to occur more during deep solar minimum of 2008-2009 than during relatively high solar condition?, and opened up the challenging unresolved science problems to the diverse scientific community to understand the mystery of nature. These outstanding questions remain mostly unanswered and call for extensive experimental and theoretical works to understand the mystery of the equatorial ionosphere, especially the solar-terrestrial energetic and the Sun-Earth linkage in general.

Now the NARL scientists, in coordination with scientists from other ISRO centers, are planning to carry out rocket-borne measurements concurrently with the radar experiments using the newly established active array MST radar and the Gadanki Ionospheric Radar Interferometer (GIRI) and theoretical simulation to resolve the outstanding science questions.



Inverse Relationship between the Intensity of the Echoes and Solar EUV Radiation

GSLV Successfully Launches South Asia Satellite

India's Geosynchronous Satellite Launch Vehicle (GSLV-F09) successfully launched the 2230 kg South Asia Satellite (GSAT-9) into its planned Geosynchronous Transfer Orbit (GTO) today (May 05, 2017). Today’s launch of GSLV was its eleventh and took place from the Second Launch Pad at the Satish Dhawan Space Centre SHAR (SDSC SHAR), Sriharikota, the spaceport of India. This is the fourth consecutive success achieved by GSLV carrying indigenously developed Cryogenic Upper Stage. In its oval shaped GTO, the South Asia Satellite is now orbiting the Earth with a perigee (nearest point to Earth) of 169 km and an apogee (farthest point to Earth) of 36,105 km with an orbital inclination of 20.65 deg with respect to the equator.

Few seconds before the launch countdown reached zero, the four liquid propellant strap-on motors of GSLV-F09, each carrying 42 tons of liquid propellants, were ignited. At count zero and after confirming the normal performance of all the four strap-on motors, the 139 ton solid propellant first stage core motor was ignited and GSLV lifted off at 16:57 IST. The major phases of the flight occurred as scheduled. About seventeen minutes after lift-off, South Asia Satellite was successfully placed in GTO.

Soon after separation from GSLV, the two solar arrays of the satellite were automatically deployed in quick succession and the Master Control Facility (MCF) at Hassan in Karnataka assumed control of the satellite.

South Asia Satellite is a communication satellite built by ISRO to provide a variety of communication services over the South Asian region. For this, it is equipped with Ku-band transponders.

Following the successful launch, the Honorable Prime Minister of India, Mr. Narendra Modi addressed along with the South Asian leaders. He congratulated ISRO and remarked that today was a historic day for South Asia and a day without precedence. The Prime Minister recalled that two years ago India made a promise to extend the advanced space technology for the cause of growth and prosperity of the people of South Asia and felt that the successful launch of South Asia Satellite today marks a fulfillment of that.

The satellite orbit was raised to the final circular Geostationary Orbit (GSO) by firing the satellite's Liquid Apogee Motor (LAM) in stages. The South Asia Satellite was commissioned into service after the completion of orbit raising operations and the satellite’s positioning in its designated slot in the GSO following in-orbit testing of its payloads.

The Fully Integrated GSLV-F09 Carrying GSAT-9 at the Second Launch Pad

209 Foreign Satellites Launched by PSLV

Sl.	No. Name	Country	Date of Launch	Mass (Kg)	Launch Vehicle
1	DLR-TUBSAT	GERMANY	26-05-1999	45	PSLV-C2
2	KITSAT-3	REPUBLIC OF KOREA	26-05-1999	110	PSLV-C2
3	BIRD	GERMANY	22-10-2001	92	PSLV-C3
4	PROBA	BELGIUM	22-10-2001	94	PSLV-C3
5	LAPAN-TUBSAT	INDONESIA	10-01-2007	56	PSLV-C7
6	PEHUENSAT-1	ARGENTINA	10-01-2007	6	PSLV-C7
7	AGILE	ITALY	23-04-2007	350	PSLV-C8
8	TECSAR	ISRAEL	21-01-2008	300	PSLV-C10
9	CAN-X2	CANADA	28-04-2008	7	PSLV-C9
10	CUTE-1.7	JAPAN	28-04-2008	5	PSLV-C9
11	DELFI-C3	THE NETHERLANDS	28-04-2008	6.5	PSLV-C9
12	AAUSAT-II	DENMARK	28-04-2008	3	PSLV-C9
13	COMPASS-I	GERMANY	28-04-2008	3	PSLV-C9
14	SEEDS	JAPAN	28-04-2008	3	PSLV-C9
15	NLS5	CANADA	28-04-2008	16	PSLV-C9
16	RUBIN-8	GERMANY	28-04-2008	8	PSLV-C9
17-18	CUBESAT-1&2	GERMANY	23-09-2009	1 each	PSLV-C14
19	CUBESAT-3	TURKEY	23-09-2009	1	PSLV-C14
20	CUBESAT-4	SWITZERLAND	23-09-2009	1	PSLV-C14
21-22	RUBIN-9.1&9.2	GERMANY	23-09-2009	1 each	PSLV-C14
23	ALSAT-2A	ALGERIA	12-07-2010	116	PSLV-C15
24	NLS6.1 AISSAT-1	CANADA	12-07-2010	6.5	PSLV-C15
25	NLS6.2 TISAT-1	SWITZERLAND	12-07-2010	1	PSLV-C15
26	X-SAT	SINGAPORE	20-04-2011	106	PSLV-C16
27	VesselSat-1	LUXEMBOURG	12-10-2011	28.7	PSLV-C18
28	SPOT-6	FRANCE	09-09-2012	712	PSLV-C21
29	PROITERES	JAPAN	09-09-2012	15	PSLV-C21
30	SAPPHIRE	CANADA	25-02-2013	148	PSLV-C20
31	NEOSSAT	CANADA	25-02-2013	74	PSLV-C20
32-33	NLS8.1&8.2	AUSTRIA	25-02-2013	14 each	PSLV-C20
34	NLS8.3	DENMARK	25-02-2013	3	PSLV-C20
35	STRAND-1	UNITED KINGDOM	25-02-2013	6.5	PSLV-C20
36	SPOT-7	FRANCE	30-06-2014	714	PSLV-C23
37	AISAT	GERMANY	30-06-2014	14	PSLV-C23
38	NLS7.1(CAN-X4)	CANADA	30-06-2014	15	PSLV-C23
39	NLS7.2(CAN-X5)	CANADA	30-06-2014	15	PSLV-C23
40	VELOX-1	SINGAPORE	30-06-2014	7	PSLV-C23
41-43	DMC3-1, 3-2, 3-3	UNITED KINGDOM	10-07-2015	447 each	PSLV-C28
44	CBNT-1	UNITED KINGDOM	10-07-2015	91	PSLV-C28
45	De-OrbitSail	UNITED KINGDOM	10-07-2015	7	PSLV-C28
46	LAPAN-A2	INDONESIA	28-09-2015	76	PSLV-C30
47	NLS-14 (Ev9)	CANADA	28-09-2015	14	PSLV-C30
48-51	LEMUR (4 nos)	USA	28-09-2015	28 kg together	PSLV-C30

209 Foreign Satellites Launched by PSLV

Sl.	No. Name	Country	Date of Launch	Mass (Kg)	Launch Vehicle
52	TeLEOS	SINGAPORE	16-12-2015	400	PSLV-C29
53	Kent Ridge-1	SINGAPORE	16-12-2015	78	PSLV-C29
54	VELOX-C1	SINGAPORE	16-12-2015	123	PSLV-C29
55	VELOX-II	SINGAPORE	16-12-2015	13	PSLV-C29
56	Galassia	SINGAPORE	16-12-2015	3.4	PSLV-C29
57	Athenoxat-1	SINGAPORE	16-12-2015	-	PSLV-C29
58	LAPAN-A3	INDONESIA	22-06-2016	120	PSLV-C34
59	BIROS	GERMANY	22-06-2016	130	PSLV-C34
60	M3MSat	CANADA	22-06-2016	85	PSLV-C34
61	SkySat Gen2-1	USA	22-06-2016	110	PSLV-C34
62	GHGSat-D	CANADA	22-06-2016	25.5	PSLV-C34
63-74	DOVE QP3.1-3.4, QP1.1-1.4, QP2.1-2.4	USA	22-06-2016	4.7 each	PSLV-C34
75	ALSAT-1B	ALGERIA	26-09-2016	103	PSLV-C35
76	ALSAT-2B	ALGERIA	26-09-2016	117	PSLV-C35
77	ALSAT-1N	ALGERIA	26-09-2016	7	PSLV-C35
78	PATHFINDER-1	USA	26-09-2016	44	PSLV-C35
79	NLS-19	CANADA	26-09-2016	8	PSLV-C35
80-167	DOVE (Flock-3P) (88nos)	USA	15-02-2017	4.7 each	PSLV-C37
168-175	LEMUR (8 nos)	USA	15-02-2017	4.6 each	PSLV-C37
176	PEASS	THE NETHERLANDS	15-02-2017	3	PSLV-C37
177	DIDO-2	SWITZERLAND	15-02-2017	4.2	PSLV-C37
178	BGUSat	ISRAEL	15-02-2017	4.3	PSLV-C37
179	Al-Farabi-1	KAZAKHSTAN	15-02-2017	1.7	PSLV-C37
180	Nayif-1	UAE	15-02-2017	1.1	PSLV-C37
181	CE-SAT-1	JAPAN	23-06-2017	*	PSLV-C38
182	CICERO-6	USA	23-06-2017	*	PSLV-C38
183	Tyvak-53b	USA	23-06-2017	*	PSLV-C38
184-191	LEMUR-2	USA	23-06-2017	*	PSLV-C38
192	D-SAT	Italy	23-06-2017	*	PSLV-C38
193	Max Valier	Italy	23-06-2017	*	PSLV-C38
194	URSAMAIOR	Italy	23-06-2017	*	PSLV-C38
195	Venta-1	Latvia	23-06-2017	*	PSLV-C38
196	SUCHAI-1	Chile	23-06-2017	*	PSLV-C38
197	QB50-BE06	Belgium	23-06-2017	*	PSLV-C38
198	UCLSst	Belgium	23-06-2017	*	PSLV-C38
199	InflateSail	Belgium	23-06-2017	*	PSLV-C38
200	QB50- DE04	Germany	23-06-2017	*	PSLV-C38
201	Aalto-1	Finland	23-06-2017	*	PSLV-C38
202	PEGASUS/AT03	Austria	23-06-2017	*	PSLV-C38
203	skCUBE	Slovakia	23-06-2017	*	PSLV-C38
204	LituanicaSAT-2	Lithuania	23-06-2017	*	PSLV-C38
205	ROBUSTA-1B	France	23-06-2017	*	PSLV-C38
206	VZLUSAT-1	Czech Republic	23-06-2017	*	PSLV-C38
207-209	The 3 Diamonds	United Kingdom	23-06-2017	*	PSLV-C38

* 243 kg together

South Asia Satellite: GSAT-9

Satellite communication continues to be one of the effective means for the developing countries in providing connectivity to the remote and inaccessible areas and provides cost effective solutions for delivering key services to common man and society at large. Considering the closer links among the countries in South Asia region and the need to nurture the bonding further, cooperation in the areas of space based services becomes indispensable. As a step towards this cooperation, India has taken initiative to build and launch a communication satellite, named as 'South Asia Satellite' (SAS) for the benefit of neighbouring countries involving Afghanistan, Bangladesh, Bhutan, Maldives, Nepal and Sri Lanka.

The South Asia Satellite was successfully launched on May 05, 2017 using indigenous launch vehicle GSLV F09 from the launch pad at SDSC, Sriharikota. While congratulating ISRO's scientists on this magnificent feat, the Honourable Prime Minister of India called it a 'historic moment'. Addressing a programme via video-conferencing with the leaders of all the countries involved in the Project, the Prime Minister said that this initiative of India opens up new horizons of engagement among the countries of the region.

The SAS is configured around ISRO's well proven I-2K bus with a lift-off mass of about 2230 Kg. The satellite generates about 3.3 KW power using its solar panels and carries two Li-Ion batteries to provide operations support during eclipse. The satellite uses conventional chemical bi-propellant as well as electrical propulsion for the first time for the station keeping operations.

The Ku-band transponders of the satellite will be capable of providing both broadcast and telecommunication services within its intended service area. The satellite is designed to facilitate each country with their own ground set-up for broadcasting their television channels and also VSAT services like E-governance, disaster management support, ATMs, etc., with dedicated satellite resources. Some of the services that are beneficial to the member nations are:

- **Banking/ATM services:** Using the satellite, every member country can setup their own autonomous nationwide banking network especially in remote areas of their nation to improving their local-banking requirements.

- **E-governance:** Each country can establish their own countrywide independent satellite network for accessing government schemes by its citizen.

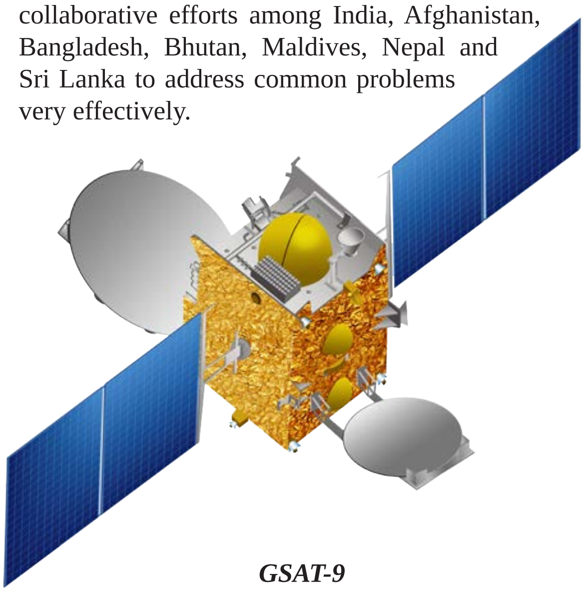
- **Cellular backhaul:** Connectivity to remote regions of each country can be facilitated by nationwide cellular backhaul networks through satellite where terrestrial solution does not exist.

- **Disaster Management Support:** Satellite can facilitate establishing an emergency communication system during disaster. All the disaster-prone areas in a country can be connected to the central emergency operations centre through satellite, enabling designated authorities in making faster decisions, providing directions through timely monitoring and assessment.

It is also planned to establish a common ground infrastructure for connecting all the member nations to support the activities, in a collaborative manner, in the area of Meteorological Data transmission, networking of academic and research institutions, etc.

In order to enable test television transmission in the national languages of Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, and Sri Lanka, India has established required ground station facility in New Delhi. The facility will also support the demonstration of interactive services to member nations.

South Asia Satellite will play a significant role in addressing connectivity solutions of socio-economic developments in the region. The satellite will be another milestone for demonstrating the collaborative efforts among India, Afghanistan, Bangladesh, Bhutan, Maldives, Nepal and Sri Lanka to address common problems very effectively.



GSAT-9

ISRO Develops "Solar Calculator" Android App

Computation of solar energy potential is essential to select the locations for Solar PhotoVoltaic (PV) thermal power plants. The use of remote sensing observations from geostationary satellite sensors is ideal to capture space-time variability of surface insolation. An android App for the computation of solar energy potential has been developed by Space Applications Centre (SAC), ISRO, Ahmedabad at the behest of Ministry of New and Renewable Energy, Government of India. It is a very useful tool for installation of PV solar panels for tapping solar energy.

The App provides monthly / yearly solar potential (in kWh/m2) and minimum / maximum temperature at any location. It also displays the location on the satellite image and provides azimuth / elevation angles as well as day length over different time periods in a year.

Following are the major features of the App:

- The App provides solar energy potential (in kWh/m2) at any given location
- The required location can be keyed in or can be obtained through GPS
- It gives monthly and yearly solar potential processed using Indian Geostationary Satellite data (Kalpana-1, INSAT-3D and INSAT-3DR). It also offers monthly minimum and maximum temperature to calculate realistic solar potential
- Location is displayed on image with satellite data in the background
- It also provides azimuth and elevation angles, and day length over different time periods in a year.
- Obstruction of sunlight due to terrain is also calculated using Digital Elevation Model (DEM)
- It also suggests optimum tilt angle for solar PV installation
- This App needs internet connection to calculate the results
- Complete report can be saved as a PDF file

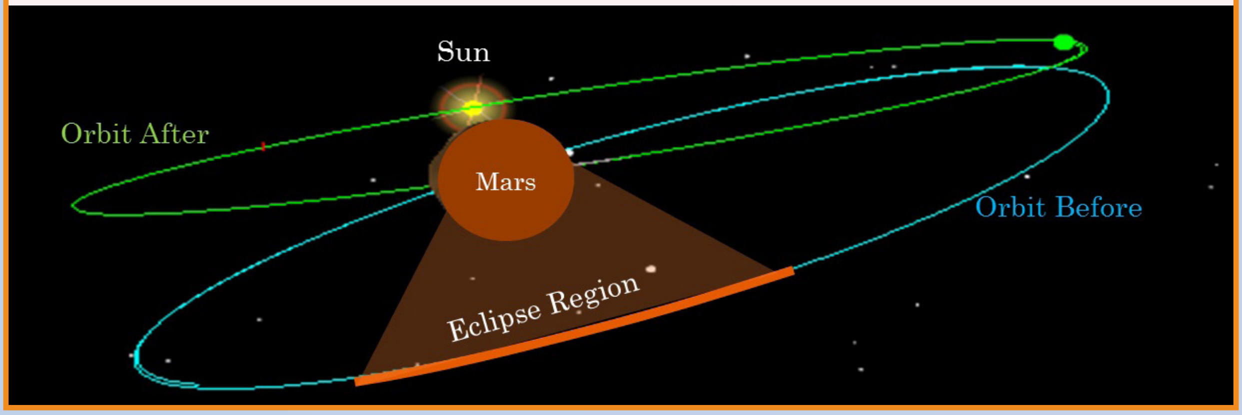
The App can be downloaded from "New and Renewable Energy" section at vedas.sac.gov.in

Long Eclipse Avoidance Manoeuvres Performed Successfully on MOM Spacecraft

An orbital manoeuvres was performed on Mars Orbiter Mission (MOM) spacecraft to avoid the impending long eclipse duration for the satellite. The duration of the eclipse would have been as long as 8 hours in the coming days. As the satellite battery is designed to handle an eclipse duration of only about 1 Hour 40 minutes, a longer eclipse would have drained the battery beyond the safe limit. The manoeuvres performed on January 17, 2017 brought down the eclipse duration to zero during this long eclipse period.

On the Evening of January 17, all the eight numbers of 22N thrusters were fired for a duration of 431 seconds, achieving a velocity difference of 97.5 m/s. This has resulted in a new orbit for the MOM spacecraft, which completely avoids eclipse up to September 2017. About 20 kg propellant was consumed for this manoeuvres leaving another 13 kg of propellant for its further mission life.

The spacecraft health is normal. The next long eclipse period for MOM is expected in the year 2020.



Eclipse Avoidance Manoeuvres on MOM Spacecraft

Satish Dhawan Wind Tunnel Complex Commissioned at VSSC

In the quest to reduce the cost of access to space and to extend the frontiers of space exploration, ISRO has ventured into Reusable Launch Vehicle (RLV) and Re-entry missions, Air-breathing propulsion technology demonstration and Interplanetary missions. These missions encounter design criticalities at Hypersonic Mach number regime and need rigorous aero-thermodynamic characterisation at these Mach numbers. In order to cater to the above need, Industrial type Hypersonic Wind Tunnel and Shock Tunnel have been established at Vikram Sarabhai Space Centre (VSSC).

The first phase of the facility, commissioned in 2012, with Mach 6 system and Shock Tunnel, has been extensively utilised and tests are being carried out for the current programs of ISRO.

The second phase of Hypersonic Wind tunnel consists of the realisation of Mach 8, 10 and 12 nozzles, Heater-II system, Hot Shut-off Valves, Cooling system and associated subsystems. Realisation of these systems involved intricate design and analysis, high precision machining, heavy engineering hardware realisation, fabrication of high temperature performance materials, high temperature and high pressure valves realisation, development of state of the art Cored Bricks as heat storage media, realisation of massive 15-5 PH forgings and high temperature heating modules. Integration of these systems was carried out meticulously, performance assessment was made and trial runs were conducted to calibrate and validate the tunnel systems.

With capability up to Mach 12 operation, Hypersonic Wind Tunnel is the third largest in the world in terms of hypersonic flow simulation capability over a wide spectrum. The tunnel has the capability to simulate flow field conditions at Mach 6, 8, 10 and 12 of nominal nozzle exit diameter of 1 metre with Reynolds number ranging from 1 to 80 million per metre. The tunnel is pressure-vacuum driven with high pressure storage system of 300 bar and vacuum system of 10-2 mbar capacity. Regenerative storage heater system is used to preheat the compressed air up to 1550 K before it is expanded through the nozzle to Hypersonic Mach number. The state-of-the-art technology is used for data acquisition and control of the tunnel system. Programmable Logic Controller (PLC) based system works on Dual redundant Hot Standby concept and monitors more than 100 input parameters and controls more than 60 events. The shock tunnel uses combustion driver and has the capability to simulate free stream velocities up to 4.5 km/s and a maximum Reynolds number of 3.3 million per metre.

The realisation of the above facilities paved the way for the indigenous development of technologies, in the area of Cored Bricks, Hot Shut off Valves and massive 15-5 PH forgings. Hot Shut-off Valves, the most critical valve in the tunnel circuit with simultaneous application of high pressure and high temperature of 110 bar and 1550 K respectively, have been indigenously developed. High temperature Heater system demanded high purity Alumina Cored Bricks, of low dust characteristics and high temperature thermal shock resistance, as heat storage media. These were jointly developed by ISRO and Indian industries. Massive 15-5 PH forgings with integral flanges are realised for the high pressure shock tubes designed to withstand 1000 bar and associated fatigue cycles.

The major systems of the tunnel are designed to meet the requirement of five blow downs per day. It consists of 500 valves, 2 km pipelines, 40 numbers of electric motors and 35 fluid pumps. These facilities have been indigenously designed, developed and made with the support of Indian Industries.

This Integrated Hypersonic Wind Tunnels facility has been commissioned by Chairman, ISRO / Secretary, DOS, during March 2017. The entire complex, consisting one metre Hypersonic Wind Tunnel, one metre Shock Tunnel and Plasma Tunnel was named as "Satish Dhawan Wind Tunnel Complex" as a tribute to Prof. Satish Dhawan, who has made very significant contributions in the field of wind tunnels and aerodynamics.

1m Hypersonic Wind Tunnel at VSSC

ISRO Organises Smart India Hackathon-2017 Grand Finale

Indian Space Research Organisation (ISRO), Department of Space (DOS), organised Smart India Hackathon-2017 (SIH-2017) Grand Finale, at Gujarat University Convention Hall, Ahmedabad, Gujarat during April 01-02, 2017 for Ahmedabad Nodal Centre. This Grand Finale was a 36 hours non-stop digital programming competition held simultaneously at 29 different Nodal Centers (26 Locations) across India.

ISRO/DOS has chosen "Information and Cyber Security" as a theme for this Smart India Hackathon-2017. There has been a significant rise in the use of cyber technologies in various space mission support functions within ISRO/DOS, which has posed new challenges to ISRO's IT and space assets security apart from the usual dealing with highly confidential and sensitive data related to space missions. Thus, deterrent measures against cyber attacks as well as enforcing data security measures to create proactive security monitoring capability are vital for ISRO. With this objective, Information and Cyber Security as a focus for this SIH-2017 was selected to get novel ideas from India's Young and Ignited minds to resolve specific issues in their own innovative ways.

53 Problems were posted by ISRO/DOS covering the categories like Network and Email Security, Data Confidentiality and Leakage Prevention, End point / Perimeter Security against Cyber-Attacks, Access Control and Other Applications etc., Out of the 263 idea submissions received, 50 ideas had been short-listed. Towards training the various student participants, online training session was also organised by ISRO on March 08, 2017. During the 'Grand Finale' at Ahmedabad, on April 01-02, 2017, 49 teams consisting of 392 youngsters (6 students & 2 mentors per team) participated and worked non-stop for 36 hours to build innovative digital solutions for 21 out of 53 the problems posed by ISRO/DOS.

Honb'le Prime Minister, Shri Narendrabhai Modi, addressed all the participants across India on the night of April 01, 2017 (22:00-23:00 Hrs), and also interacted via Live Video Conference with student participants of Ahmedabad Nodal Centre along with those of Allahabad, Coimbatore, Kolkota and Pune Centres. Chairman ISRO / Secretary DOS, and Chairman, AICTE, were present on the evening of April 01, 2017 to attend this event as well as to encourage and motivate the student participants at night.

Honb'le Education Minister of Gujarat, Director SAC, Vice Chancellors of Gujarat Technological University (GTU) and Gujarat University were the Chief Guests at the inaugural function of SIH-2017 held on April 01, 2017. The Valedictory function and the prize distribution were held on April 02, 2017. Student participants had lively and vibrant interactions with Chairman ISRO and asked many questions related to ISRO's current and future space programmes.

Out of 5 prizes sponsored, Winner Prize (Rajalakshmi Engineering College, Kanchipuram, Chennai, Tamil Nadu), First Runner-Up (Thiagarajar College of Engineering, Madurai, Tamil Nadu.) and Second Runner-Up (Nitte Meenakshi Institute of Technology, Bengaluru, Karnataka.) received ISRO Trophies. All the participating teams got certificates and Mementos.

ISRO/DOS had been the 'Premier Partner' in this initiative of All India Council for Technical Education (AICTE) under the aegis of Ministry of Human Resource Development.

36-hours Hackathon underway at Gujarat University Convention Hall, Ahmedabad

ISRO signs Three MoUs with Government of Andhra Pradesh for use of Geo-spatial Technology

Government of Andhra Pradesh (Govt. of AP) signed Memorandum of Understandings (MoUs) with ISRO for the deployment of space technology in governance and development of the State. Following are the three MoUs signed for utilisation of geo-spatial technology in Meteorological Services, Disaster Management and Water Resources Management:

1. MoU between Govt. of AP and Satish Dhawan Space Centre SHAR (SDSC SHAR), ISRO, Sriharikota for experimental meteorological services to the State.

   Andhra Pradesh Varuna, an android mobile App was also released on this occasion. This App makes use of Automatic Weather Stations and Ground Water Piezometers, installed across the state, as well as weather forecast data from ISRO to provide required weather parameters:

   - Current weather (Rainfall, Temperature, Humidity, Wind Speed and Direction, Ground Water Levels) from 1800 Automatic Weather Stations and 1200 Ground Water Piezometers
   - Next 24 hrs forecast at six hourly intervals
   - Next 7 days forecast

2. MoU on Disaster Management Support (DMS) with National Remote Sensing Centre (NRSC) ISRO, Hyderabad using Space-based inputs.

   The scope of the MoU involves customisation of near real time space based inputs for Andhra Pradesh on natural disasters, customised mobile Apps for collection of field data etc., The DMS is extended to the natural disasters like floods, cyclones, forest fires, earthquakes, landslides and tsunami.

3. MoU on development of web-based geo-portal "AP State Water Resources Information and Management System (APWRIMS)" signed between Water Resources Department, Govt. of Andhra Pradesh (WRD-AP) and NRSC.

   The APWRIMS will host all the spatial and non-spatial data of water resources sector of the State. The system is expected to facilitate seamless ingestion of real-time field data, facilitate water resources inventory through satellite observations and validated models, constitute decision support tools, water audit, etc. NRSC would provide requisite technical know-how, training and guidance to WRD-AP.

The MoUs were signed on March 15, 2017 at Gannavaram near Vijayawada in Andhra Pradesh in the presence of Honourable Chief Minister of Andhra Pradesh, and Chairman, ISRO / Secretary, Dept. of Space. Director, SDSC-SHAR, Director, NRSC, Scientific Secretary of ISRO, Senior Officials from NRSC, SDSC-SHAR and Govt. of Andhra Pradesh were also present during the event.

Andhra Pradesh has been extensively using Space based inputs for societal applications and these MoUs reiterate its commitment to extend these applications with the help of ISRO.

ISRO Joins 36th Indian Scientific Expedition to Antarctica

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 for a long time. This year, in the 36th Indian scientific expedition, four teams from ISRO (one from Space Applications Centre (SAC) Ahmedabad with two members, one from National Remote Sensing Centre (NRSC) Hyderabad with four researchers, one from Indian Institute of Remote Sensing (IIRS) Dehradun with one scientist and one from Space Physics Laboratory (SPL) VSSC Thiruvananthapuram with three members) have participated.

Climate change is the thrust area of the 36th Indian Scientific Expedition to Antarctica (36-ISEA). The main objective of this expedition is to install stakes on ice for Differential Global Positioning System (DGPS) measurements around Bharati and Maitri to validate glacier surface velocity derived from satellite data to estimate thickness of snow over land and sea ice using Ground Penetrating Radars (GPR's) and also to verify conditions of snow over sea and land ice.

SAC is participating in the research activities in the area of Cryosphere under its Earth Observation Program. Cryospheric studies on the earth surface include the inventory, dynamics, changes, and interaction with hydrosphere, atmosphere etc., of snow, ice cover on land, sea ice and permafrost. The expedition team carried out helicopter based aerial surveys and collected data over the Antarctica ice-sheet, fast ice and sea ice floe. Bamboo stakes were installed over Polar Record glacier for measuring glacier surface ice velocity. The accurate coordinates of these stakes were recorded using DGPS. GPR data of various Antarctic ice features were collected at three different frequencies of 400 MHz, 500 MHz and 1GHz. It may be noted that 500 MHz GPR was indigenously developed by SAC.

Apart from collecting field data, the team at SAC also monitored sea ice status near Bharati and Maitri coasts of Antarctica using real time satellite data from newly launched SCATSAT-1 and other satellites, for accurate navigation of expedition ship.

Four researchers from NRSC were also participated in the 36-ISEA. Three of them have participated in voyage, carrying out scientific observations on board ship enrouted to Antarctica on green house gases and aerosols. The team have carried out measurements at Bharati and Maitri stations and also covering transaction between Bharati and Maitri station (about 3000 KM).

Following are the research activities in the area of climate change studies and Atmospheric studies:

- **Study of snow melt/freeze dynamics in Antarctica using space based and ground based observations:** Under ongoing project of NRSC, observations using snow fork were collected over six locations near Bharati station, Antarctica during November 2016 to January 2017. The observations included snow density, wetness and profile temperature in 26 pits dug on sheet ice.

- **Measurements of Atmospheric Black Carbon (BC), GHGs and solar radiation fluxes at Antarctica on a long-term basis:** The objectives of the project are to generate base line concentrations of atmospheric constituents such as CO2, CH4, H2O, which are being measured by ultra portable Greenhouse Gas Analyser/Licor CO2 analyser. BC measurement for long-range transport from populated mid and low latitude regions and its presence over pristine Antarctic environments is being measured using Aethalimeter-AE31. Microtops sun photometer is used to measure Columnar Aerosol Optical depth (AOD), Water vapour and Ozone.

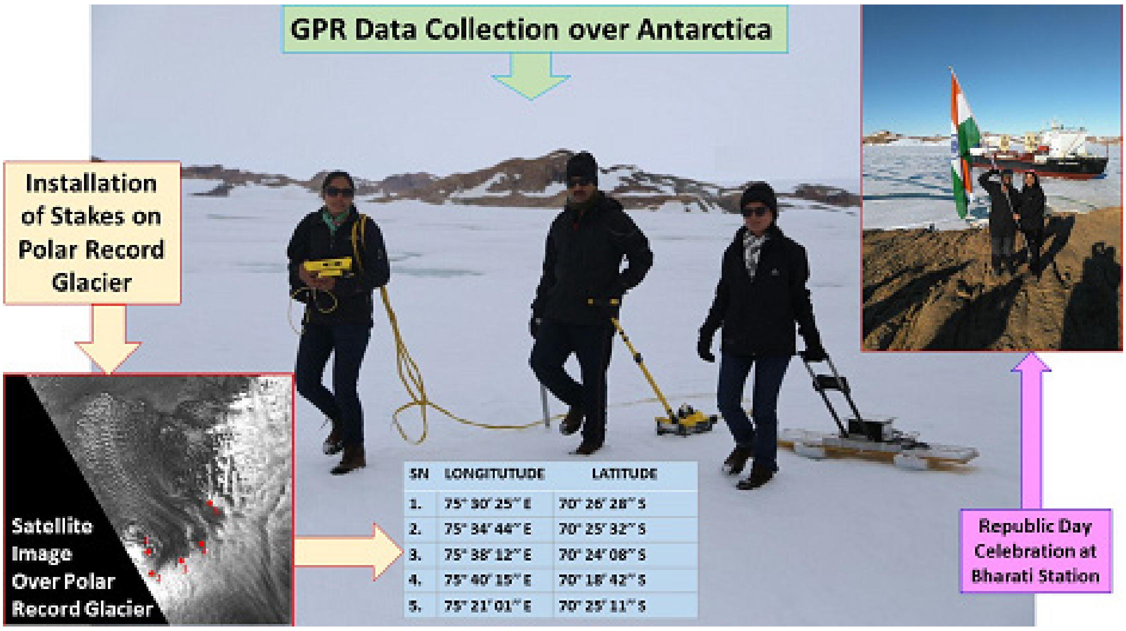
- **Image measurements of visibility to investigate atmospheric parameters:** The objectives of the project are to estimate atmospheric visibility in horizontal and vertical (zenith) direction; estimation of atmospheric extinction in horizontal and vertical directions using CCD camera equipped with low power laser and laptop. CCD Camera is being used to get the contrast variation or quantifiable visibility, which in turn can be used to estimate the particulate matter over the Antarctica.

- **Study on long term precipitation over Antarctica using surface and space-based measurements:** The rate of atmospheric precipitation over Antarctica may have important role to global sea level variation via impact on the surface snow and ice accumulation. The objective of the project is to understand the inter-annual variability of precipitation by direct measurements of Antarctic precipitation features such as the frequency, the phase, and the snowfall rate and also validation of CloudSat satellite data retrievals of precipitation over Antarctica.

Study from IIRS includes "Validation of remote sensing and model based Antarctica Ice sheet features and glacier landforms". Extensive field campaigns were conducted jointly with Geological Survey of

India (GSI) in Wohlthat Mountains and Schirmacher oasis area near Mairti station during November 03, 2016 to February 24, 2017 as both studies have common objectives and study area.

SPL has conducted experiments in the areas of Polar Atmosphere and Polar Ionosphere. The scientific activities in the area of polar atmosphere include studies on atmospheric aerosols, chemistry, atmospheric boundary Layer, thermodynamics and coupling processes. These studies are carried out by making measurements of aerosol black carbon, by collecting snow and aerosol samples, balloon borne measurements of wind, temperature, humidity and ozone, measurement of boundary layer parameters using sonic anemometers as well as surface level measurements of various trace gases. In the area of Polar Ionosphere, studies are conducted to understand the impact of solar wind at the high and low latitude regions.



Snow Fork Observations in Pit

NARL Celebrates Silver Jubilee of Establishment of MST Radar

A high power 53 MHz Mesosphere-Stratosphere-Troposphere (MST) Radar was established in 1992 as a national facility for atmospheric research at National Atmospheric Research Laboratory (NARL), Department of Space (DOS), Government of India, Gadanki. The MST Radar is a state-of-the-art instrument capable of providing estimates of atmospheric parameters with very high resolution on a continuous basis.

As part of the Silver Jubilee of the establishment of the high power MST Radar, NARL organised the third Regional Conference on Radio Science 2017 (URSI-RCRS 2017) during March 1-4, 2017 at Tirupati, jointly with the Indian Committee for URSI (INCURSI) under the Indian National Science Academy (INSA).

International Union of Radio Science (URSI) promotes all aspects of radio science under ten Commissions - Electromagnetic Metrology, Fields and Waves, Radio Communication Systems and Signal Processing, Electronics and Photonics, Electromagnetic Environment and Interference, Wave Propagation and Remote Sensing, Ionospheric Radio and Propagation, Waves in Plasmas, Radio Astronomy, Electromagnetics in Biology and Medicine.

INCURSI started this series of conferences covering Africa and South Asian region to encourage and promote radio science research as well as interdisciplinary interaction among researchers from the sub-fields of radio science, at a periodicity of about eighteen months. The first conference was organised in January 2014 at Symbiosis University, Pune and the second conference in November 2015 at Jawaharlal Nehru University, New Delhi. The number of delegates have been increasing and the present conference has more than 280 registered participants. A total of 200 papers were presented in ten Commissions during URSI-RCRS 2017, out of which 26 were invited talks, 79 contributed talks and 95 posters presentations.

A special session to mark the beginning of the Silver Jubilee year of Indian MST Radar was organised at the conference, which talks about the origin, design, development, installation and utilisation of the radar were presented by the engineers and scientists associated with it. A detailed exposition of the initiation of the idea of ground based remote sensing of Earth atmosphere under Indian Middle Atmosphere Programme was provided during the conference. Intricacies and challenges of low radio noise site selection, project design, implementation and operational phases over past 25 years, were described by the associated senior and young scientists and engineers.

Young Scientist and Student Paper Competition (SPC) awards are special feature of URSI-RCRS, wherein young scientists under the age of 35 years and students registered for Ph.D or M.Tech Students with some research experience are encouraged to participate in the conference by submitting good quality papers and prizes are given. There were 21 YSA entries out of which eight were shortlisted for final presentation. Five YSA prizes were awarded (1st , 2nd, 3rd and two honorable mention). For SPC, there were 25 entries out of which 10 were shortlisted for final presentations. Five SPC prizes were awarded (1st , 2nd, 3rd and two honorable mention).

The conference sessions during first three days are conducted at Fortune Select Grand Ridge Hotel, Tirupati. The final day's sessions were organised at NARL Gadanki, to give the participants an exposure of experimental facilities of NARL. In the valedictory session, it was mentioned by the General Chairs that the third URSI-RCRS had given a tremendous boost to Radio Science and that it would now serve as an excellent impetus to the forthcoming URSI Asia Pacific Radio Science Conference (AP-RASC 2019) to be held in New Delhi during March 9-15, 2019. The Commission Chairs appreciated the participation of many new Young Scientists apart from Distinguished Scientists from India and abroad and the excellent organisation of the conference.

The third URSI-RCRS was inaugurated by Sri A.S. Kiran Kumar, Chairman ISRO on March 01, 2017 at Tirupati. He elaborated on the emerging opportunities in semiconductors, remote sensing, frontline propulsion systems, nano and micro satellites. He gave a call to the serious researchers, young scientists and students to take up the challenging problems in these emerging areas and reiterated the strong support and commitment of ISRO to the advancement of radio science in the country.

Chairman, ISRO, also released a video documentary on NARL and unveiled the announcements of the two forthcoming conferences planned during the Silver Jubilee year of Indian MST Radar, namely, "Understanding, Predicting and Projecting Climate Change over Indian Region (UPCAR)" during June 26-28, 2017, in collaboration with SV University Tirupati and "India Radar Meteorology (IRad) Conference" during January 08-11, 2018 in collaboration with Ministry of Earth Sciences (MoES), Government of India.

PSLV-C37 Successfully Launches 104 Satellites in a Single Flight

In its thirty ninth flight (PSLV-C37), ISRO's Polar Satellite Launch Vehicle successfully launched the 714 kg Cartosat-2 Series Satellite along with 103 co-passenger satellites today morning (February 15, 2017) from Satish Dhawan Space Centre SHAR, Sriharikota. This is the thirty eighth consecutively successful mission of PSLV. The total weight of all the 104 satellites carried on-board PSLV-C37 was 1378 kg.

PSLV-C37 lifted off at 0928 hrs (9:28 am) IST, as planned, from the First Launch Pad. After a flight of 16 minutes 48 seconds, the satellites achieved a polar Sun Synchronous Orbit of 506 km inclined at an angle of 97.46 degree to the equator (very close to the intended orbit) and in the succeeding 12 minutes, all the 104 satellites successfully separated from the PSLV fourth stage in a predetermined sequence beginning with Cartosat-2 series satellite, followed by INS-1 and INS-2. The total number of Indian satellites launched by PSLV now stands at 46.

After separation, the two solar arrays of Cartosat-2 Series Satellite were deployed automatically and ISRO's Telemetry, Tracking and Command Network (ISTRAC) at Bangalore took over the control of the satellite. In the coming days, the satellite will be brought to its final operational configuration following which it will begin to provide remote sensing services using its panchromatic (black and white) and multispectral (colour) cameras.

Of the 103 co-passenger satellites carried by PSLV-C37, two – ISRO Nano Satellite-1 (INS-1) weighing 8.4 kg and INS-2 weighing 9.7 kg – are technology demonstration satellites from India.

The remaining 101 co-passenger satellites carried were international customer satellites from USA (96), The Netherlands (1), Switzerland (1), Israel (1), Kazakhstan (1) and UAE (1).

Cartosat -2 Series Satellite

The Cartosat-2 series satellite is the primary satellite carried by PSLV-C37. This satellite is similar to the earlier four satellites of the Cartosat-2 series. After its injection into a 505 km polar Sun Synchronous Orbit by PSLV-C37, the satellite was brought to operational configuration following which it began providing regular remote sensing services using its Panchromatic and Multi-spectral cameras.

The imageries from Cartosat-2 series satellite will useful for cartographic applications, urban and rural applications, coastal land use and regulation, utility

Fully Integrated PSLV-C37 seen with Mobile Service Tower management like road network monitoring, water distribution, creation of land use maps, change detection to bring out geographical and manmade features and various other Land Information System (LIS) and Geographical Information System (GIS) applications.

ISRO Nano Satellites: INS-1A & INS-1B

PSLV-C37 also carried two ISRO Nano satellites INS-1A and INS-1B as co-passenger satellites. These two satellites carries a total of four different payloads from ISRO's Space Applications Centre (SAC) and Laboratory for Electro Optics Systems (LEOS) for conducting various experiments.

INS-1A: INS-1A carries Surface Bidirectional Reflectance Distribution Function Radiometer (SBR) payload from Space Applications Centre (SAC), Ahmedabad measures the BRDF (Bidirectional Reflectance Distribution Function) of the Earth surface and will take readings of the reflectance of different surface features due to Sun albedo. It also carries Single Event Upset Monitor (SEUM) payload from SAC monitors Single Event Upsets occurring due to high energy radiation in the space environment.

INS-1B: INS-1B carries Earth Exosphere Lyman Alpha Analyser (EELA) payload from Laboratory for Electro-Optics Systems (LEOS), Bengaluru Registers terrestrial exospheric line-of-sight neutral atomic hydrogen Lyman Alpha flux. Besides, it will estimate the interplanetary hydrogen Lyman-alpha background flux by means of deep space observations. Origami Camera payload from SAC is a Remote Sensing Colour camera with a novel lens assembly for optical realisation in a small package. There is scope for its future scalability and utilisation in regular satellites.

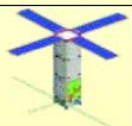
Customer Satellites

Of the 101 Nano satellites from abroad carried as co-passenger payloads, 96 are from United States of America and the other five are from Israel, Kazakhstan, the Netherlands, Switzerland and the UAE. These International customer satellites together weigh about 663 kg at launch.

DOVE (Flock-3P) Nano satellites (88 Nos) [USA]: DOVE Flock-3P satellites are a fleet of remote sensing satellites that will image the entire Earth every day for commercial, environmental and humanitarian purposes. The Dove satellites are designed, built and operated by Planet, headquartered in San Francisco, USA. The 88 Dove satellites will be housed inside 22 QuadPack dispensers. The total mass of 88 Dove satellites along with QuadPack dispenser is 570 kg.

Lemur Satellites (8 Nos) [USA]: LEMUR satellites are nano satellites of Spire Global Inc. (San Francisco, CA), USA. The mission objective of LEMUR satellites is to provide vessel tracking using Automatic Identification System (AIS), besides carrying out weather measurement using GPS Radio Occultation. The total mass of eight Lemur satellites with QuadPack dispenser is about 50 kg.

Nano satellites from The Netherlands, Switzerland, Israel, Kazakhstan and UAE

Nano Satellite	Country	Built by	Objective
PEASSS (3 kg) 	The Netherlands	European consortium of Partners owned by Innovative Solutions In Space BV	Technology demonstrator nano satellite
DIDO-2 (4.2 kg) 	Switzerland	SpacePharma	Microgravity research nano satellite
BGUSat (4.3 kg) 	Israel	Israeli Aerospace Industries (IAI), in cooperation with the Ben Gurion University	Technology demonstrator for nano satellite avionics systems
Al-Farabi-1 (1.7 kg) 	Kazakhstan	Al-Farabi Kazakh National University (KazNU named after Al-Farabi)	Technology demonstrator nano satellite
Nayif-1 (1.1 kg) 	UAE	Mohammed bin Rashid Space Centre, Dubai	Technology demonstrator nano satellite

The Unique Triumph of PSLV-C37

On February 15, 2017, PSLV-C37, the 39th mission of the workhorse launch vehicle of ISRO, injected ISRO's Cartosat-2 Series Satellite weighing 714 kg and two ISRO Nano-satellites namely INS-1A (8.4 kg) & INS-1B (9.7 kg) and 101 Nano-satellites, from six foreign countries into a Sun-Synchronous Orbit (SSO) at an orbit of 506 km above earth, with an inclination of 97.46°. The mass of nano-satellites varied from 1 to 10 kg. The total weight of all the 104 satellites carried on-board PSLV-C37 was 1378 kg.

The large number of satellites in this mission demanded adopting innovative approaches in satellite accommodation and mission design.

Apart from conventional satellite adapters, namely, Payload Adapter (PLA) and Multiple Satellite Adapter (MSA), six numbers of custom made adapters were newly configured and used to house the nano satellites. Some of these adapters allowed multi tier mounting of satellites and few of them were accommodated on the Vehicle Equipment Bay itself. This architecture enabled the optimal utilisation of the payload volume as well as capability.

Next requirement was managing safe separation of these large numbers of satellites within the constraints of limited visibility duration of ground stations and maintaining safe distance between the separated satellites over a longer period of time.

This was managed by designing a unique sequencing and timing for separating the satellites and with complex manoeuvering of PS4 stage to which satellites are attached. The separation sequence, direction and timing were finalised based on extensive study to ensure safe distance among the 105 objects (including PS4 stage) in orbit, which renders 5460 number of pairs.

The next major requirement was to ensure reaching separation command from launcher to respective satellites honoring the predefined sequence, which involves a complex electrical wiring scheme. Any error in the wiring may result in release of wrong satellite leading to undesirable situation of collision between them.

Another innovative feature in this mission was capturing all the separation events of vehicle stages and 104 satellites using a comprehensive video imaging system onboard.

Meticulous planning was done at launch complex, SDSC SHAR on assembling and handling of all sub systems and satellite preparation. Apart from launching SSO, sub GTO and multi orbit missions, PSLV has established once again as a workhorse vehicle to undertake very complex missions like PSLV-C37.

Lift - off of PSLV-C37

Indigenous Development of Telemetry & Telecommand Processor (TTCP)

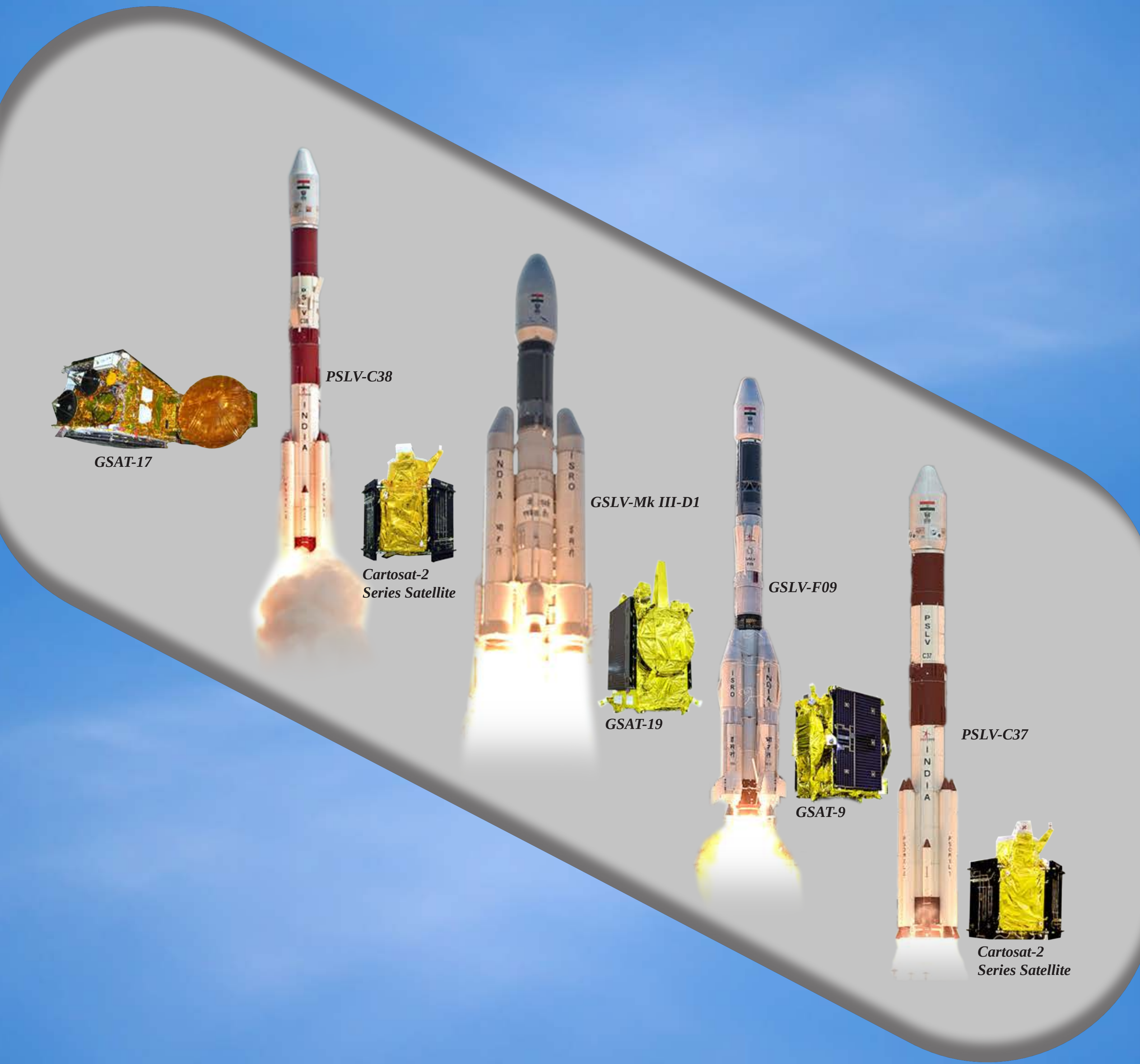
ISRO Satellite Centre (ISAC), Bengaluru, is the lead centre for conceptualisation, design, development, fabrication, integration and testing of complex satellite technology. Spacecraft Checkout Group of ISAC is responsible for integrated spacecraft testing to ensure the flight worthiness of the spacecraft built at ISAC. During the testing, ground systems will communicate to spacecraft via the same uplink and downlink signals, as in space. The spacecraft typically use ISRO formats for telemetry and telecommand (downlink and uplink), for which indigenous equipment are being used. However, the interplanetary spacecraft use an international standard known as CCSDS - Consultative Committee for Space Data Systems. Presently equipment are being imported for telemetry reception and telecommand transmission requirements.

As part of ‘Make in India’ campaign, indigenous development of Telemetry & Telecommand Processor (TTCP) was taken up by ISRO and successfully realised. This processor replaces the expensive imported equipment. This will be used in Integrated Spacecraft Testing of Low Earth Orbit, Geostationary Orbit and Interplanetary Spacecraft. This system is configurable to meet uplink and downlink requirements of both CCSDS and ISRO standards. Multiple Clients can remotely access this system for data and monitoring. Productionisation of this system will be initiated with the help of Indian industry.

The system was developed on an FPGA (Field Programmable Gate Array) platform taking advantage of System On Chip (SOC) features. Telemetry & Telecommand sections were realised as separate hardware. Telemetry input can be received at 70 MHz Intermediate Frequency (IF) and Pulse Code Modulation (PCM) level. Telecommand outputs are available at PCM, Frequency Shift Keying (FSK) / Phase Shift Keying (PSK) and 70 MHz IF. All the features of TTCP are programmable remotely, using the soft-core processor onboard FPGA. A computer with server software is used for configuration management, remote monitoring, Telemetry data streaming, Telecommand echo and secured access for Telecommand & Control from multiple remote clients. This system is an amalgamation of diverse software, hardware devices and digital signal processing techniques which work in tandem to provide the required functionalities.

This indigenously developed Processor was successfully deployed for the first time in checkout of GSAT-19, which was launched later on June 05, 2017 from SDSC SHAR, Sriharikota.

Telemetry & Telecommand Processor (TTCP)



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