अन्तरिक्ष भारत

SPACE INDIA

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Indian Space Research Organisation

जनवरी - जून 2015 Januaruy - June 2015

The Indian Space Programme

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

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

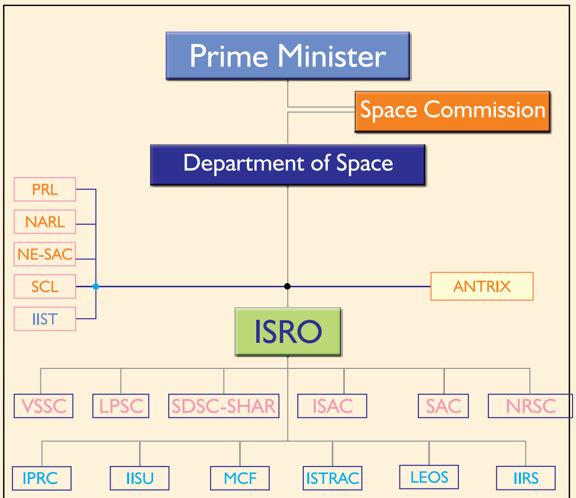
- Indian National Satellite (INSAT) programme for telecommunications, TV broadcasting, meteorology, developmental education, etc.
- Remote Sensing programme for the application of satellite imagery for various developmental purposes
- Indigenous capability for design and development of spacecraft and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

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

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

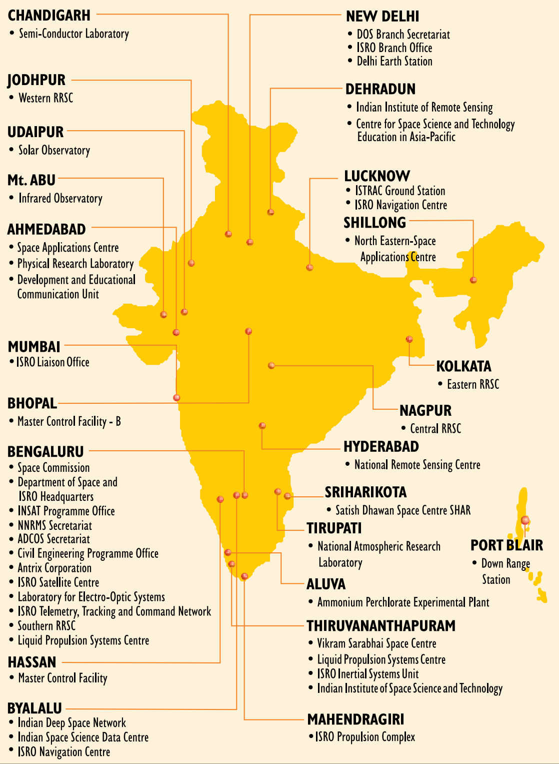
Both the DOS and ISRO Headquarters are located at Bengaluru. The developmental activities are carried out at the Centres and Units spread over the country.

So far, 78 Indian Satellite Missions (including satellites built by students, SRE-1 and CARE Module) and 46 Launches from Sriharikota have been conducted.



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

The Centres of Indian Space Programme



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PSLV-C27 Successfully Launches India's Fourth Navigation Satellite IRNSS-1D

ISRO's Polar Satellite Launch Vehicle, PSLV-C27, successfully launched the 1425 kg IRNSS-1D, the fourth satellite in the Indian Regional Navigation Satellite System (IRNSS) on March 28, 2015 from Satish Dhawan Space Centre SHAR, Sriharikota. This was the twenty eighth consecutively successful mission of PSLV. The 'XL' configuration of PSLV was used for this mission. Previously, the same configuration of the vehicle was successfully used seven times.

After the PSLV-C27 lift-off at 1719 hrs IST from the Second Launch Pad with the ignition of the first stage, the subsequent important flight events, namely, strap-on ignitions and separations, first stage separation, second stage ignition, heat-shield separation, second stage separation, third stage ignition and separation, fourth stage ignition and satellite injection, took place as planned. After a flight of about 19 minutes 25 seconds, IRNSS-1D Satellite was injected to an elliptical orbit of 282.52 km x 20,644 km (very close to the intended orbit) and successfully separated from the PSLV fourth stage. After injection, the solar panels of IRNSS-1D were deployed automatically. ISRO's Master Control Facility (at Hassan, Karnataka) took over the control of the satellite. Subsequently, four orbit manoeuvres were conducted to position the satellite in the Geosynchronous Orbit at 111.75 deg East longitude with 30.5 deg inclination.

IRNSS-1D is the fourth of the seven satellites constituting the space segment of IRNSS. IRNSS-1A,

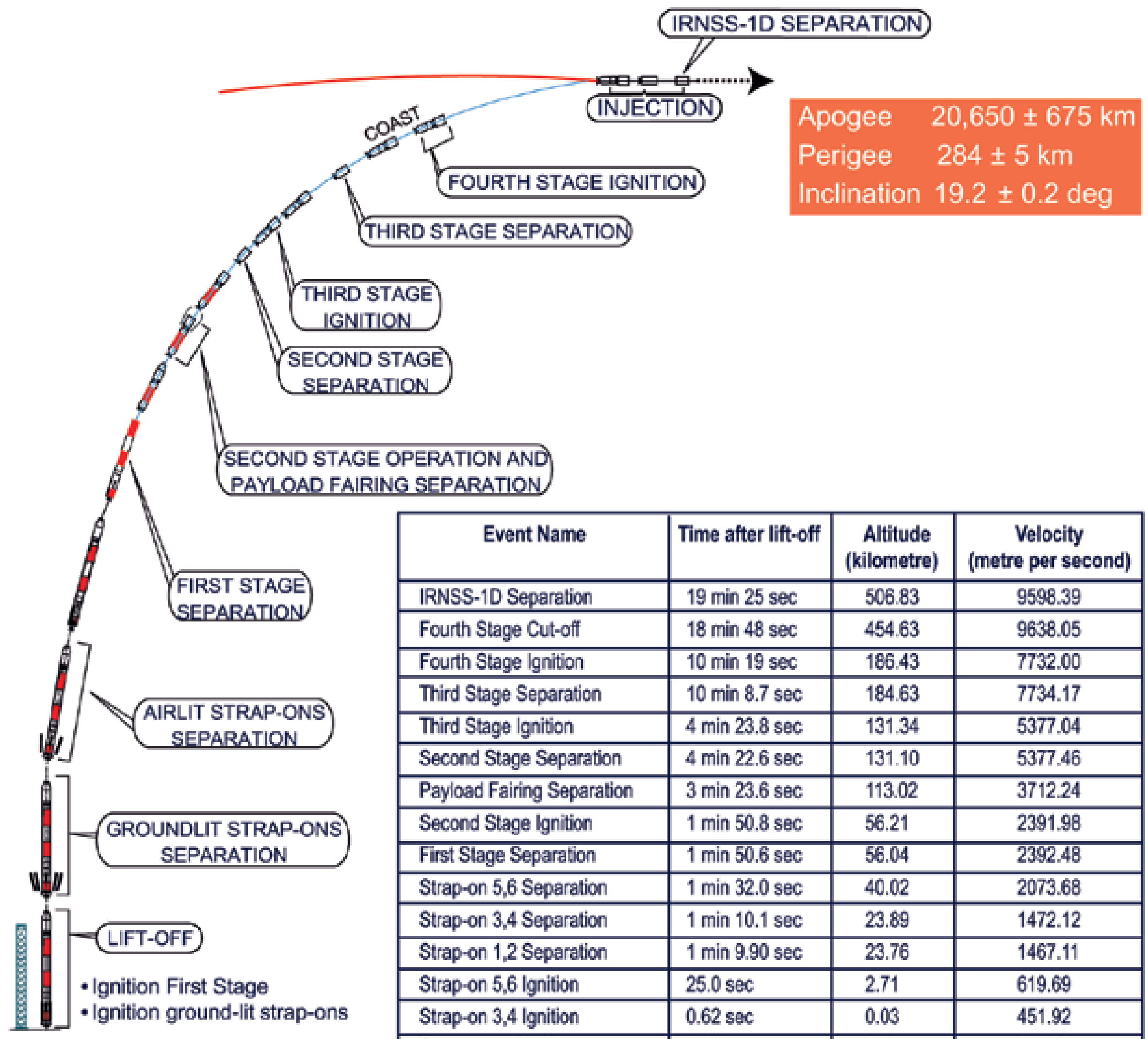
PSLV-C27 Lifts-off

PSLV-C27 at a glance (Vehicle lift-off Mass: 320 tonne Height: 44.4 m)

	Stage-I	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass (T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Max Thrust (kN)	4819 (Core), 6 x 716 (Strap-on)	804	240	7.3 x 2
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

HTPB : Hydroxyl Terminated Poly Butadiene, UH25: Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate, N_2O_4: Nitrogen Tetroxide, MMH: Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C27 Typical Flight Profile



Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
IRNSS-1D Separation	19 min 25 sec	506.83	9598.39
Fourth Stage Cut-off	18 min 48 sec	454.63	9638.05
Fourth Stage Ignition	10 min 19 sec	186.43	7732.00
Third Stage Separation	10 min 8.7 sec	184.63	7734.17
Third Stage Ignition	4 min 23.8 sec	131.34	5377.04
Second Stage Separation	4 min 22.6 sec	131.10	5377.46
Payload Fairing Separation	3 min 23.6 sec	113.02	3712.24
Second Stage Ignition	1 min 50.8 sec	56.21	2391.98
First Stage Separation	1 min 50.6 sec	56.04	2392.48
Strap-on 5,6 Separation	1 min 32.0 sec	40.02	2073.68
Strap-on 3,4 Separation	1 min 10.1 sec	23.89	1472.12
Strap-on 1,2 Separation	1 min 9.90 sec	23.76	1467.11
Strap-on 5,6 Ignition	25.0 sec	2.71	619.69
Strap-on 3,4 Ignition	0.62 sec	0.03	451.92
Strap-on 1,2 Ignition	0.42 sec	0.03	451.92
First Stage Ignition	0 sec	0.03	451.92

IRNSS-1D Salient Features

Orbit	Geosynchronous, at 111.75 deg East longitude with 30.5 deg inclination
Lift-Off Mass	1425 Kg
Dry Mass	603 Kg
Physical Dimensions	1.58 Metre x 1.50 Metre x 1.50 Metre
Power	Two solar panels generating 1660 W, one Lithium-Ion battery of 90 Ampere-Hour Capacity
Propulsion	440 Newton Liquid Apogee Motor, twelve 22 Newton Thrusters
Control System	Zero momentum system, orientation input from Sun & Star sensors and Gyroscopes; Reaction Wheels, Magnetic Torquers and 22 Newton thrusters as actuators
Mission Life	10 Years

1B and 1C, the first three satellites of the constellation, were successfully launched by PSLV on July 02, 2013, April 04, 2014 and October 16, 2014 respectively. All the three satellites are functioning satisfactorily from their designated orbital positions. IRNSS is an independent regional navigation satellite system designed to provide position information in the Indian region and 1500 km around the Indian mainland. IRNSS would provide two types of services, namely, Standard Positioning Services (SPS) - provided to all users – and Restricted Services (RS), provided to authorised users.

IRNSS-1D integrated with the fourth stage of PSLV-C27

IRNSS -1D carries two types of payloads – navigation payload and ranging payload. The navigation payload of IRNSS-1D will transmit navigation service signals to the users. This payload will be operating in L5 band (1176.45 MHz) and S band (2492.028 MHz). A highly accurate Rubidium atomic clock is part of the navigation payload of the satellite. The ranging payload of IRNSS-1D consists of a C-band transponder which facilitates accurate determination of the range of the satellite. IRNSS-1D also carries Corner Cube Retro Reflectors for laser ranging.

A number of ground stations responsible for the generation and transmission of navigation parameters, satellite control, satellite ranging and monitoring, etc., have been established in many locations across the country.

In the coming months, the next satellite of this constellation, namely, IRNSS-1E, is scheduled to be launched by PSLV. The entire IRNSS constellation of seven satellites is planned to be completed by 2016.

A Step Towards Satellite Based Navigation Services in India: GAGAN & IRNSS

Satellite Navigation (SATNAV) has been identified as one of the important activities in the Department of Space. Indian Space Research Organisation (ISRO) and Airports Authority of India (AAI) have jointly taken up GPS Aided Geo Augmented Navigation (GAGAN) Technology Demonstration System (TDS) as a forerunner for the operational Satellite based Augmentation System (SBAS) over the Indian Airspace. The operational phase of GAGAN has an indigenously developed satellite navigation system to cater to the requirements of critical National applications in addition to providing a back up to the present global SATNAV system being used by the commercial and other establishments in the country. In order to organise and implement the above activities effectively, a Satellite Navigation Programme was constituted.

GPS Aided GEO Augmented Navigation - GAGAN

The objective of GAGAN is to establish, deploy and certify satellite based augmentation system for safety-of-life civil aviation applications in India and this has been completed successfully.

The positional accuracy provided by a stand alone GPS receiver is typically about 10 m with no integrity. The SBAS system improves the accuracy to better than 5 m with integrity information about all the GPS satellites in view and protects the user from using unreliable/unmonitored satellites which are essential for safety of life applications.

The system is inter-operable with other international SBAS systems like US-WAAS, European EGNOS, and Japanese MSAS, etc. GAGAN GEO footprint extends from Africa to Australia and has expansion capability for seamless navigation services across the region. GAGAN provides the additional accuracy, availability, and integrity necessary for all phases of flight, from en-route through approach for all qualified airports within the GAGAN service volume. The GAGAN System signal-in-space format complies with International Civil Aviation Organisation (ICAO) standards and recommended practices for satellite-based augmentation systems.

GAGAN Payload is already operational through GSAT-8 and GSAT-10 satellites. GAGAN Signal in Space is broadcast 24x7 with PRN127 (GSAT-8) and PRN128 (GSAT-10). The third GAGAN payload will be carried onboard GSAT-15 satellite which is scheduled for launch this year. As part of GAGAN ground segment, 15 Indian reference stations for monitoring and collecting GPS/GEO data, two master control centres and three uplink stations are in continuous operations (Fig 1). All the ground elements

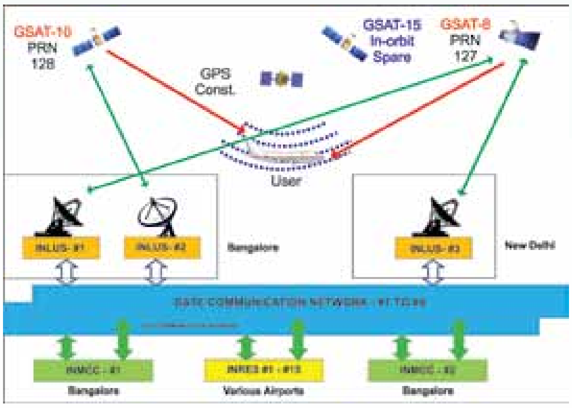


Fig 1: GAGAN Architecture

are interconnected via multiple communication links for uninterrupted operation.

Initially, Director General of Civil Aviation (DGCA), India certified GAGAN for en-route operations (RNP 0.1) on December 30, 2013 and subsequently on April 21, 2015 for precision approach services (APV 1). APV1 Certified GAGAN signals are being broadcast with effect from May 19, 2015. GAGAN is the first SBAS system in the world to serve the equatorial region. GAGAN ionospheric algorithm known as ISRO GIVE Model-Multi-Layer Data Fusion (IGM-MLDF) was developed by ISRO and is operational in the implemented GAGAN System. India has become the third country in the world to have such precision approach capabilities.

With 3 GEO satellites carrying Navigation Payload, GAGAN provides En-route support for the Indian FIR and APV1.0 service over Indian landmass (Fig 2). GAGAN, though primarily meant for aviation, will provide benefits beyond aviation to many other user segments, such as intelligent transportation, maritime, highways, railways, surveying, geodesy, security agencies, telecom industry, personal users of position location applications, etc.

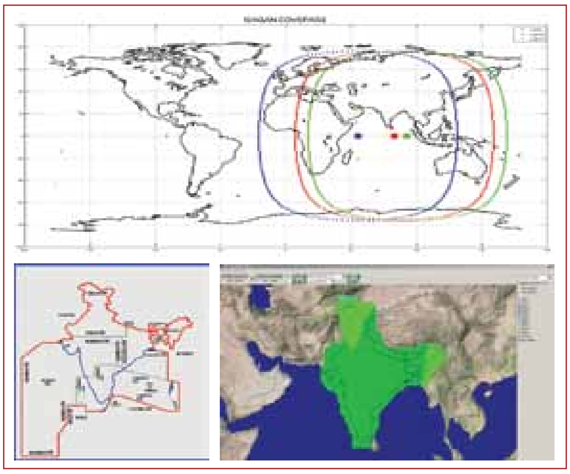


Fig 2: GAGAN FIR and APV1.0 service area

Indian Regional Navigation Satellite System - IRNSS

IRNSS is an ISRO initiative to design and develop an independent satellite-based navigation system to provide positioning, navigation and timing services for users over the Indian region. The system is designed with a constellation of 7 spacecraft and a vast network of ground systems operating 24 x 7. Three satellites of the constellation placed in geostationary orbit, at 32.5°E, 83°E and 131.5°E and four satellites in inclined geosynchronous orbit with an equatorial crossing at 55°E and 111.75°E, with an inclination of 29° (two in each plane). The constellation provides continuous regional coverage for positioning, navigation and timing services.

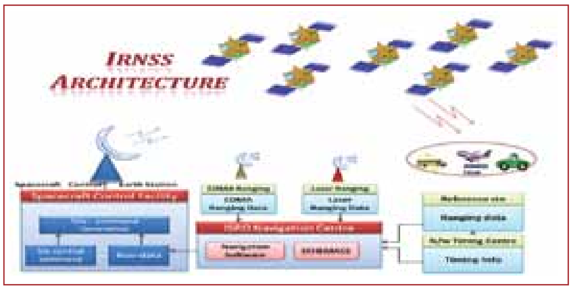


Fig 3: IRNSS Architecture

The ground segment is responsible for the maintenance and operation of the IRNSS constellation. The system is supported by a vast ground segment consisting of 17 IRIMS (1-way ranging stations), 4 IRCDR (2-way CDMA ranging stations), 2 IRNWT (Timing Centre), 2 INC (ISRO Navigation Centre) and 2 SCF (Spacecraft Control Facility) located at various parts of the country.

The IRNSS constellation transmits navigation signals in L5 and S bands. The basic services offered by IRNSS are: Standard Positioning Service (SPS) and Restricted Service (RS), that uses encryption technologies. IRNSS would provide services to the area covering India and 1500 Km around Indian land mass defined as its Primary Service Area.

Three satellites-IRNSS-1A, 1B and 1C-were launched during 2013-14. IRNSS-1D, the fourth satellite of IRNSS constellation was launched on March 28, 2015 on board PSLV-C27 and has joined the family of IRNSS space segment. With the addition of fourth spacecraft, the minimum satellite requirement is met and independent position solution is demonstrated for the first time using an Indian satellite-based navigation system. The unique Geostationary Earth Orbit (GEO)/Geosynchronous Orbit (GSO) constellation design provides a position accuracy of better than 15 m for 18 hours in a day even with 4 satellites as shown in Fig 4.

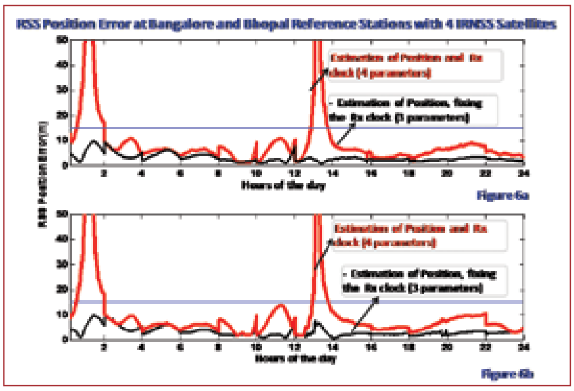


Fig 4: Positional Error at Bangalore and Bhopal over a day with 4 Satellites

Demonstrating the Proof of concept is a historic and significant milestone towards offering initial satellite navigation services from IRNSS. The first independent position fix of longitude, latitude and altitude, using IRNSS signals, was recorded on April 30, 2015, with an accuracy of 10-15 m, meeting the design objectives for four-satellite configuration. There are confirmed reports of signal reception and validation of performance from countries like China, Finland and Russia.

ISRO has released the 'IRNSS Signal-in-Space interface control document for Standard Positioning Service version 1.0', the document that comprehensively provides all the information required by user receiver manufacturers. The document is available for download at http://irnss.isro.gov.in.

While GAGAN redefines navigation over Indian Airspace, IRNSS is planned to provide independent and self reliant satellite-based navigation services over Indian region.

Dr Jitendra Singh launches Augmented Reality Application named 'Sakaar' at a Press Conference in New Delhi

The Union Minister of State (Independent Charge) Development of North-Eastern Region (DoNER), MoS PMO, Personnel, Public Grievances & Pensions, Atomic Energy and Space, Dr Jitendra Singh launched an Augmented Reality (AR) application named 'Sakaar' at a press conference in New Delhi on June 15, 2015 to highlight the achievements of the Department of Space during one year in office of the present Government. DECU-ISRO has developed this application for Android devices.

Augmented Reality is a live direct view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated 3D models, animations, videos etc. The technology enhances user's current perception of reality. Augmentation is in real time and the information is overlaid on the live view of the device's camera. Essentially, AR requires three elements: Android device with back camera, AR application, AR Markers. The Multimedia content which is embedded in the Sakaar app is generated with the support of multimedia & editing facilities of DECU-ISRO.

Sakaar consists of 3D models of MOM, RISAT, rockets (PSLV, GSLV MkIII); videos of INSAT 3Dpredicting cyclones, GSLV D5/Cryo, Mars Orbiter Mission (MOM) orbit insertion, launch video of MOM, 360 degree animated view of MOM; Anaglyph of Mars surface. The sakaar app is loaded on webpage with the URL:http://www.sac.gov.in/SACSITE/sakaar/index.html. The user can scan the QR code using a QR code reader on the device for downloading the app.

Addressing the press conference, Dr Jitendra Singh said that Department has been able to achieve a lot due to the patronage received from the Hon'ble Prime Minister of India, Shri Narendra Modi. This year has brought India's space technology to focus and established us in the world, he added. Dr Jitendra Singh said that today India is one of the leading nations in the world in the field of space technology. This is due to the commitment shown by the scientists who work with dedication and sincerity towards their work. He also said that Mars Mission is a unique success for India. This was successful in the first attempt itself and the entire infrastructure was indigenous which is in line with the Prime Minister's vision of Make in India.The images sent by Mars Orbiter Mission are being taken by other countries of the world too. The Minister also said that reusable launch vehicle which will reduce the cost of launch by one tenth and a preliminary action in this respect is expected in September this year.

Shri A. S. Kiran Kumar, Secretary Department of Space and Chairman, ISRO highlighted the achievements of Department of Space during the last one year such as the launch of PSLV-C23, IRNSS-1C, IRNSS-1D, GSAT-16, LVM3-X/Crew Module, successful ground testing of high thrust cryogenic engine for GSLV MkIII. He also said that an MoU was signed between ISRO and CNES in April, 2015 and between ISRO and China National Space Administration in September, 2014.

Mentioning about the societal applications of space technology, Shri Kiran Kumar said that utilisation of space technology for hydrological monitoring and geomorphological monitoring is of great support for National Mission for Clean Ganga. The space technology was of great help for rapid flood mapping and monitoring done on almost daily basis during the floods in Jammu and Kashmir. Four satellites based VPN nodes were established at critical locations in Kashmir for communication. During the Cyclone Hudhud also, the cyclone tracking and landfall prediction was done. He said that space technology has applications in diversified areas including forestry, national urban Information system, watershed development, agriculture, fisheries, monitoring irrigation infrastructure, etc.

The ISRO Chairman informed that various missions are planned for the upcoming year 2015-16 including launch of PSLV-C28 in July, GSLV–D6 in August, ASTROSAT in September this year among others. The launch of IRNSS-1F and IRNSS-1G are planned for beginning of the next year 2016, he informed.

Senior officials of the Department of Space were also present during the press conference.

Cartosat-1 Completes a Decade in Orbit

The launch of Cartosat-1 Satellite on May 5, 2005 heralded a new era in Indian Remote Sensing Applications with the unique configuration of payloads (Fore PAN camera at +26 degree and Aft PAN camera at -5 degree) to provide along track stereo imagery at 2.5 m resolution for applications in the areas of cartography, large scale topographic mapping, etc.

One of the major achievements of Cartosat-1 data is the generation of national level Digital Elevation Model (DEM) at one third arc second and ortho image base at one twelfth arc second for the entire country. The generation of CartoDEM involves handling large volumes of satellite data in raster format, which was automated using the indigenously developed Augmented Stereo Strip Triangulation (ASST) software. The software has used about 2800 Ground Control Points (GCPs), generated specifically for Cartosat-1 data processing. Further, to facilitate the Indian user community in general and academic community in particular, CartoDEM of 30 m posting was made available at free of cost through Bhuvan portal of ISRO and till date about 74,000 products have been downloaded by the users. The Cartosat-1 Stereo data has also been validated by global community to generate high quality DEM under Cartosat-1 Scientific Assessment programme (C-SAP).

Some of the major applications carried out using Cartosat-1 data include (i) generation of urban base map at 1:10,000 scale for National Urban Information System for 152 towns (ii) Generation of large scale topographic map at 1:10,000 scale for cartographic applications (iii) Generation of Digital Terrain Model (DTM) with bare earth orthometric heights for the Indian coasts on vulnerability of inundation due to Tsunami and Cyclone for Indian National Centre for Ocean Information Services (INCOIS) (iv) Estimating the status of irrigation potential created and in identification of critical gaps for 103 Irrigation projects under Accelerated Irrigation Benefit Programme (AIBP) (v) Generation of State level DEM and mosaic of ortho-images at State levelunder Space based Information Support for Decentralised Planning (SIS-DP) (vi) Planning of watershed and its concurrent monitoring and evaluation at periodic intervals (vii) India-Water Resource Information System (India-WRIS), etc.

Till now, nearly one lakh imagery have been disseminated to the user community. The unique nature of imaging and the quality products of Cartosat-1 has created a keen interest amongst the International user community and about 12 Ground Stations (Germany, Russia, China, Algeria, Iran) were setup to directly download the Cartosat-1 data to generate the high resolution DEMs and Cartographic applications.

Today, Cartosat-1 based datasets have become standard products for Bhuvan in high resolution image reference and development of many national level and state level natural resources development applications and management programmes in different themes. These include agriculture, urban planning, water resources, landslide studies, glacier studies, ground water potential zonation, disaster management support, rural development, forest biomass estimation, etc.

Though designed for a mission life of 5 years, Cartosat-1 has served more than 10 years and is still beaming high quality along track stereo imagery. On this occasion, a one day National seminar "Cartosat-1: 10 years in orbit" was organised at National Remote Sensing Centre (NRSC), Hyderabad on May 05, 2015, to deliberate on the achievement of Cartosat-1, potential use of the data by user community and the future requirements. A comprehensive compendium "Cartosat-1: 10 Years Completion (2005-2015)" was brought out on this important occasion.

About 350 participants from Central and State government organisations including Ministry of Urban Development, Ministry of Forest and Environment, Ministry of Water Resources, Ministry of Agriculture and State Remote Sensing Application Centres (SRSACs), Scientists and Engineers of different ISRO Centres, namely, NRSC, ISAC, ISTRAC, SAC, ADRIN as well as participants from Industry attended the seminar. Contributions of all Scientists/ Engineers were acknowledged on this landmark event. The future high resolution satellites and the payload capabilities presented to the users evinced keen interest among the user community.

Release of Cartosat-1–10 Years Completion Compendium

High Thrust Cryogenic Engine (CE20) Development

ISRO is developing a high thrust cryogenic engine to be used for the upper stage of its heavy lift launch vehicle GSLV Mk-III. This high thrust cryogenic engine produces a nominal thrust of 196.5 kN in vacuum with a specific impulse of 434 seconds. The engine works on "Gas Generator Cycle" which has flexibility for independent development of each sub-system before the integrated engine test, thus minimising uncertainty in the final developmental phase and reducing development time. This engine generates nearly 2 MW power as compared to 1 MW generated by the engine of Cryogenic Upper Stage (CUS) engine of GSLV. The high thrust cryogenic engine is one of the most powerful cryogenic engines of upper stages in the world.

A major milestone in the development of ISRO's next generation launch vehicle, GSLV MkIII, was achieved on successful long duration hot test (635 seconds) of high thrust cryogenic engine (CE20) on April 28, 2015 at ISRO Propulsion Complex (IPRC), Mahendragiri, Tamil Nadu. The CE20 cryogenic engine is being indigenously developed by ISRO to power the cryogenic stage of GSLV MkIII launch vehicle.

CE20 Engine

The completion of successful long duration hot test has once again proved ISRO's capability in mastering the complex cryogenic technology. All subsystems of this engine such as Thrust Chamber, Injector, Gas Generator, LOX & LH2 Turbopumps, Control Components, Pyro systems etc., and the ground Test Facility systems performed very well and the parameters are well within the prediction.

A series of development tests on this engine are being carried out to validate the performance and to prove the design of the engine. Two cold start tests and four short duration hot tests have already been carried out on this engine at IPRC, Mahendragiri.

The high thrust cryogenic engine is designed and realised by Liquid Propulsion Systems Centre (LPSC) at Valiamala with the support of Vikram Sarabhai Space Centre (VSSC) at Thiruvananthapuram. The engine assembly, integration and testing was carried out by IPRC at Mahendragiri. Indian Industries have significantly contributed in the realisation of this cryogenic engine.

While ground tests conducted so far validate this the design adequacy and performance of the integrated engine, further demonstration tests are planned at engine and stage level to characterise the different performance parameters under various operating conditions. After completion of these tests, the indigenous high thrust cryogenic engine and stage are planned to be flight tested in GSLV Mk-III-D1 mission.

A S Kiran Kumar takes over as Secretary, Department of Space, Chairman, Space Commission and Chairman, ISRO

Mr Alur Seelin Kiran Kumar, Distinguished Scientist (Apex) and Director, Space Applications Centre, Ahmedabad, assumed the office of the Secretary, Department of Space, Chairman, Space Commission and Chairman, Indian Space Research Organisation (ISRO) on January 14, 2015.

Born on October 22, 1952 in Hassan, Karnataka, Shri Kiran Kumar completed his B.Sc. Physics in 1971 from Bangalore University, M.Sc. (Electronics) in 1973 from the same University and M. Tech. (Physical Engineering) in 1975 from Indian Institute of Science. Mr Kiran Kumar began his career in ISRO by joining Space Applications Centre (SAC) in 1975. Later, he became its Associate Director and in March 2012 took over as the Director of SAC.

During his career span of four decades at SAC, he has made immense contributions to the development of more than 50 Electro-Optical Imaging Sensors operating from Airborne, Low Earth Orbit (LEO) and Geostationary Earth Orbit (GEO) platforms - starting from the Bhaskara TV payload that led to evolution of observation strategy encompassing, land, ocean and atmosphere. Data received from these missions have been the backbone of a good number of application programmes of the country formulated towards ensuring food and water security, sustaining environment and eco-system, understanding weather and climate, monitoring and management of natural resources, planning and monitoring of developmental activities, support to management and mitigation during disaster events, and information for better governance.

As the Director, SAC, Shri Kiran Kumar has steered the design, development, realisation and application development activities of communication, navigation, microwave and optical remote sensing payloads developed at the centre and looked after the overall administrative management of the centre.

He has made significant contributions to the development of a number of critical spacecraft technologies by participation in the review process during preliminary design, detailed design, critical design and pre-shipment reviews of low earth orbit satellites, geostationary satellites and planetary mission satellites as chairman/member of the committees, including the Mission Readiness Reviews, Launch Authorisation Board of PSLV, GSLV missions and Integrated technical review of GSLV-Mark III.

He has designed and developed several electro-optical sensors, high resolution radiometers, multichannel imaging and sound instruments for INSAT series of satellites. He has introduced concepts like apparent velocity reduction and push broom technology. For topographical/land applications, he developed a 3 tier imaging concept from coarse and high resolution swath adopted for IRS-1C to Resourcesat-2 and development of the highest spatial resolution along track stereo payload for Cartosat-1 mission which resulted in realisation of Digital Elevation Model (DEM) for the entire country have been carried out under his guidance. He has also made notable contributions to the development of space-borne synthetic aperture radar for India's first microwave imaging satellite RISAT-1.

He was instrumental in evolving the successful strategy for steering the Mars Orbiter Spacecraft towards planet Mars as well as its Mars Orbit Insertion. Apart from the similar role he played in Chandrayaan-1, he was involved in the innovative design, development and realisation of optical payloads like Mars Colour Camera, Methane Sensor for Mars, and Thermal Infrared Imaging Sensor, post launch tracking activities, orbit raising, trans-mars injection, navigation, Martian orbit insertion, high precision orbit maneuvers (pre/post insertion), payload operations and operationalisation of data processing.

Shri Kiran Kumar has been duly recognised nationally and internationally for contributions to various areas in the domain of space in many forums. He is a Fellow of professional institutions like Indian National Academy of Engineering, Indian Society of Remote Sensing, Institution of Electronics & Telecommunication Engineers, and Indian Meteorological Society. Besides, he is a member of the International Academy of Astronautics. He has represented ISRO in international forums like World Meteorological Organisation (WMO), Committee on Earth Observation Satellites (CEOS) and Indo-US Joint Working Group on Civil Space Cooperation. He has been the CEOS Chair during 2012.

He is a recipient of many national and international laurels/awards including the Padma Shri Award conferred by the President of India in 2014, International Academy of Astronautics' Laurels for Team Achievement Award for Cartosat in 2008 and for Chandrayaan-1 in 2013, Indian Society of Remote Sensing (ISRS) Award for the year 1994, VASVIK award (Electronic sciences and technology) for the year 1998, Astronautical Society of India Award (Space Sciences and Applications) for the year 2001, ISRO individual Service Award 2006, Bhaskara Award of ISRS in 2007 and ISRO Performance Excellence Award 2008.

Tapan Misra Takes Over as Director of Space Applications Centre, Ahmedabad

Mr Tapan Misra, Outstanding Scientist and Deputy Director, Microwave Remote Sensing Area of ISRO's Space Applications Centre (SAC), Ahmedabad, has assumed the office of the Director, SAC.

Mr Tapan Misra graduated in Electronics and Telecommunication Engineering from Jadavpur University, Calcutta in 1984. He was awarded the prestigious Sir J C Bose National Talent Search (JBNSTS) Scholarship in 1981. He began his career at SAC as digital hardware engineer responsible for the development of Quick Look Display System of X-band Side Looking Airborne Radar in the year 1984. Later, he became the lead member of the team which designed and developed C-band Airborne Synthetic Aperture Radar (SAR). He developed an important algorithm for real time processing of SAR data during his tenure as Guest Scientist in German Aerospace Agency (DLR) in 1990.

Mr Tapan Misra mainly contributed to the system design, simulation, integration, checkout and ground calibration for Multi-frequency Scanning Microwave Radiometer instrument which was carried on-board India's OCEANSAT-1 satellite. Following this, he led the team which developed a special airborne radar system called DMSAR (SAR for Disaster Management) during 2005-06. He also led the development of Scatterometer payload of Oceansat-2, launched in 2009, which provided valuable wind related data to global meteorological community. He was the lead designer for the development of C-band Synthetic Aperture Radar of India's Radar Imaging Satellite-1 (RISAT-1). His leadership has led to the development of critical technology elements essential to RISAT in partnership with Indian industry.

Thus, since 1984, Mr Tapan Misra has been responsible for system design, planning and development of Microwave Remote Sensing Payloads of ISRO. As Deputy Director responsible for Microwave Remote Sensors Area, he has led the team to develop futuristic remote sensing systems including a variety of advanced Radars, millimetre wave Sounders and an advanced Scatterometer. Mr Tapan Misra is also heading the Office of Innovations Management of ISRO at ISRO Headquarters, Bengaluru.

Mr Tapan Misra was awarded Hari Om Ashram Prerit Vikram Sarabhai research Award in 2004 and ISRO Merit award in 2008 for his contribution to the development of SAR technology. He was elected as Fellow of Indian National Academy of Engineering in 2007. He was also elected as Corresponding Member of International Academy of Astronautics in 2008. He has 2 granted patents, 6 pending patents, 5 copyrights and many research papers to his credit.

Dr M Annadurai Takes Over as Director of ISRO Satellite Centre, Bengaluru

Dr M Annadurai, Programme Director of Indian Remote Sensing Satellites (IRS) and Small Satellite Systems (SSS) of ISRO Satellite Centre (ISAC), Bengaluru, has assumed the office of Director, ISAC on April 01, 2015. He took over as Director, ISAC from Dr S K Shivakumar, who superannuated on March 31, 2015.

Born on July 2, 1958, Dr Annadurai graduated in Electronics and Communication Engineering from Government College of Technology, Coimbatore, obtained his Post Graduate degree in Applied Electronics from PSG College of Technology, Coimbatore and Doctoral degree from Anna University, Coimbatore.

Joining ISRO in 1982, Dr Annadurai began his career at ISAC as the team leader to design and develop Software Satellite Simulator. During the period 1992 -2005, Dr Annadurai was the lead member of ISRO's satellite mission team and managed eight INSAT Missions as the Mission Director and brought about the efficient ground automation for satellite operations. As Project Director, Dr Annadurai made the most crucial contribution to the realisation of India's first Lunar Mission, Chandrayaan-1, which won many appreciations and awards including the prestigious Space Pioneer Award, 2009. In 2011, Dr Annadurai became the Programme Director of Indian Remote Sensing Satellites (IRS) and Small Satellite Systems (SSS) and realised five satellite projects. His other major contribution is the realisation of the successful Mars Orbiter Mission in record time. Dr Annadurai also supervised two student satellite projects.

Dr Annadurai has received many awards and honours. Notable among them are Team Excellence Award from ISRO for his Contribution to Indian Space Programme (2007), National Aeronautical Award-2008 from Aeronautical Society of India, Rajyotsava Award for Science (2008) from Government of Karnataka, Hari Om Ashram Prerit Vikram Sarabhai Research Award (2004), PRL, Ahmedabad, C.P.A. Adithanar Literary Award 2013, Vivekananda Human Excellence Award, 2014 from Ramakrishna Mission, Doctor of Science conferred by five Universities, American Institute of Aeronautics and Astronautics Space Systems Award, 2009, Certificate of Appreciation from Boeing Asia-America Professional Association, USA and Laurels for Team Achievement – Chandrayaan-1 from International Academy of Astronautics, 2013, Beijing. Dr Annadurai is a Fellow of The Society for Shock Wave Research and a member of International Lunar Network Enabling Technologies Group. He is also the Chairman of Indian Remote Sensing Society (ISRS), Bangalore Chapter. Dr Annadurai has 75 papers to his credit and is the supervisory guide for four PhD works. He has authored three books.

2015 Space Pioneer Award to ISRO for Mars Orbiter Mission

Space Pioneer award for the year 2015 was presented to Indian Space Research Organisation (ISRO) in the Science and Engineering category during the 34th Annual International Space Development Conference held at Toronto in Canada during May 20 -24, 2015.

National Space Society (NSS) of USA presented this award in recognition of ISRO's efforts in accomplishing Mars Mission in its very first attempt.

India realised her mission to Mars in the very first attempt, an historical feat by any space faring individual nation. Team "Mars Orbiter Mission (MOM)" has built the spacecraft with five scientific payloads within a record time of 18 months and launched it on November 5, 2013. The spacecraft and its payloads performed as designed during the 300 days journey, traversing about 666 million kilometers in interplanetary space before entering the Mars Orbit on September 24, 2014. The spacecraft is in an elliptical orbit and the high resolution camera onboard MOM is configured to take full-disk color imagery of Mars at apoareion and close-ups at periareion. MOM has outlived the "Prime" mission life of 6 months in Mars orbit and continues to deliver scientifically significant datasets. Team MOM has proficiently handled the scientific, technical, managerial and financial aspects of the mission.

In 2009, NSS has presented a similar award to ISRO in recognition of the great accomplishment they had made in the success of the Lunar Probe, Chandrayaan-1.

National Space Society (NSS) is an independent nonprofit educational membership organisation dedicated to the creation of a space faring civilisation. The Space Pioneer Award consists of a silvery pewter Moon globe cast by the Baker Art Foundry in Placerville, California, from a sculpture originally created by Don Davis, the well-known space and astronomical artist.

New Directors for Three Major ISRO Centres: June 01, 2015

Dr K Sivan, Distinguished Scientist and Director, Liquid Propulsion Systems Centre (LPSC), Thiruvananthapuram, has assumed the office of the Director, Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram. He took over as Director, VSSC from Mr M Chandradathan, who superannuated in end May 2015.

Dr Sivan graduated from Madras Institute of Technology in Aeronautical Engineering in 1980 and took his Master's degree in Aerospace Engineering from the Indian Institute of Science (IISc), Bengaluru in 1982. Subsequently, he completed his PhD in Aerospace Engineering from the Indian Institute of Technology, Bombay in 2006.

Dr Sivan joined ISRO in 1982 to Polar Satellite Launch Vehicle (PSLV) Project and has made rich contributions towards end-to-end mission planning, mission design, mission integration and analysis. The mission design process and innovative mission design strategies perfected by him for PSLV has become the foundation for ISRO launch vehicles like Geosynchronous Satellite Launch Vehicle (GSLV), GSLV Mk-III, as well as Reusable Launch Vehicle-Technology Demonstrator (RLV-TD).

Dr Sivan is the chief architect of 6D trajectory simulation software SITARA which is the backbone of the real time and non real time trajectory simulations of all ISRO launch vehicles. He developed and implemented an innovative 'day of launch wind biasing' strategy which has made possible rocket launch on any day of the year under any weather and wind conditions.

Dr Sivan has made immense contribution towards establishing a parallel computing facility and Hypersonic wind tunnel facility, which has opened new avenues in the area of Computational Fluid Dynamics and self-reliance in wind tunnel testing. He evolved novel strategies for launching India's Mars Orbiter spacecraft through PSLV. He also led the RLV-TD development programme and spearheaded its design, qualification, aerodynamic characterisation and hardware development. Dr Sivan joined GSLV Project in April 2011 as Project Director. Under his leadership, GSLV with indigenous Cryogenic Upper Stage achieved historical success on January 05, 2014.

During his career at ISRO, Dr Sivan held many responsible positions like Project Director, RLV-TD; Deputy Director, VSSC; Project Director, GSLV and Director, LPSC.

He has numerous publications to his credit and is a Fellow of Indian National Academy of Engineering, Aeronautical Society of India and Systems Society of India.

Dr Sivan has received many awards, which include Dr Biren Roy space science award for the year 2011, ISRO merit award for the year 2007 and Shri Hari Om Ashram Prerit Dr. Vikram Sarabhai Research award for the year 1999.

Mr. S Somanath, 'Outstanding Scientist' and Associate Director (Projects), Vikram Sarabhai Space Centre (VSSC), as well as Project Director of GSLV Mk-III, has taken over as the Director of Liquid Propulsion Systems Centre (LPSC). He took over as Director from Dr K Sivan, who has taken over as the Director of VSSC.

Mr. Somanath is an expert in a host of disciplines including launch vehicle design and has specialised in launch vehicle systems engineering, structural design, structural dynamics, integration designs and procedures, mechanism design and pyrotechnics.

Mr Somanath completed graduation in Mechanical Engineering from TKM College of Engineering, Quilon, Kerala University. Later, he took Master's Degree in Aerospace Engineering from IISc, Bengaluru with specialisation in Dynamics and Control. He joined VSSC in 1985 and was associated with PSLV Project during its early development phase. As a member of the vehicle integration team, he was responsible for the system integration design and subassembly realisation and testing the stages of PSLV during its development. He was a team leader for the first and second developmental flights of PSLV.

Later, as Project Manager, Vehicle Engineering and Launch Services Management of PSLV Project, he was responsible for the mechanisms and pyro-technique systems of the vehicle. And, as satellite launch service manager, he co-ordinated the launches of commercial mini satellites in PSLV-C2 and C3 missions, and the development of small satellite accommodation systems and separation systems for mini satellites.

As the convenor, Mr Somanath authored the Project report of GSLV Mk-III (also known as LVM3) during 2000-2002 and joined GSLV Mk-III Project in 2003. Later, he became the Deputy Project Director responsible for Vehicle Engineering and Mission design, Structural Design and Integration. Mr. Somanath became the Project Director of GSLV Mk-III in 2010.

He became the Deputy Director of VSSC's Structures Entity during 2012-13 and was responsible for all the structural design, analysis and testing activities related to launch vehicle structural systems. He was also the Deputy Director of 'Propulsion and Space Ordinance Entity', which handles propulsion research activities, especially those related to solid motors and the design and development of pyro systems, till November, 2014. Under his leadership, LVM3-X/CARE mission, the first experimental suborbital test flight of LVM3, was successfully accomplished on December 18, 2014.

Mr Somanath is the recipient of many awards and honours, including the Gold Medal from IISc, Bengaluru for the Masters Programme and 'Space Gold Medal' from Astronautical Society of India. He has also received the Performance Excellence award from ISRO in the year 2009 and Team excellence award for GSLV Mk-III realisation.

Mr Somanath participated in International Astronautical Federation Congress (IAF-2012) held at Prague in 2012, launch activities of ISRO satellites on Ariane-5 at Kourou, French Guyana, mission reviews for GSAT missions at ESA, Paris and customer spacecraft interface at KAIST, South Korea. He was a member of the Indian delegation to UN-COPUOS, Vienna in 2013. He has published papers in many areas that include structural dynamics and control, dynamic analysis of separation mechanisms, vibration/acoustic testing, launch vehicle design and launch services management.

Mr P Kunhikrishnan, Deputy Director, Vikram Sarabhai Space Centre (VSSC), has taken over as the Director of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. He took over as Director from Dr M Y S Prasad, who superannuated by end May 2015.

Mr Kunhikrishnan obtained his B-Tech degree in Electronics & Communication from College of Engineering, Trivandrum. He joined ISRO in the Systems Reliability Entity of VSSC in 1986. In his career spanning over three decades in ISRO, Mr Kunhikrishnan has made significant contributions in the area of System level Quality Assurance of Avionics, Electrical Integration and Checkout Systems for various Launch Vehicles of ISRO. He was responsible for the flight certification of all the Avionics Systems of Launch Vehicles as Head of the Quality Division for Devices and Test & Evaluation.

Mr Kunhikrishnan became the Associate Project Director of PSLV in February, 2009. He assumed charge as the Project Director of PSLV Project in June 2010 and has successfully accomplished 13 PSLV Missions as Mission Director. These include such significant missions like PSLV-C19 that carried RISAT-1, the heaviest Indian remote sensing satellite launched by PSLV to Sun Synchronous Orbit so far, PSLV-C21 and PSLV C-23, two missions that successfully launched two French operational Earth Observation Satellites to intended orbits, PSLV-C25 that launched India's Mars Orbiter Spacecraft and the four PSLV missions that launched first four satellites of the Indian Regional Navigation Satellite System (IRNSS).

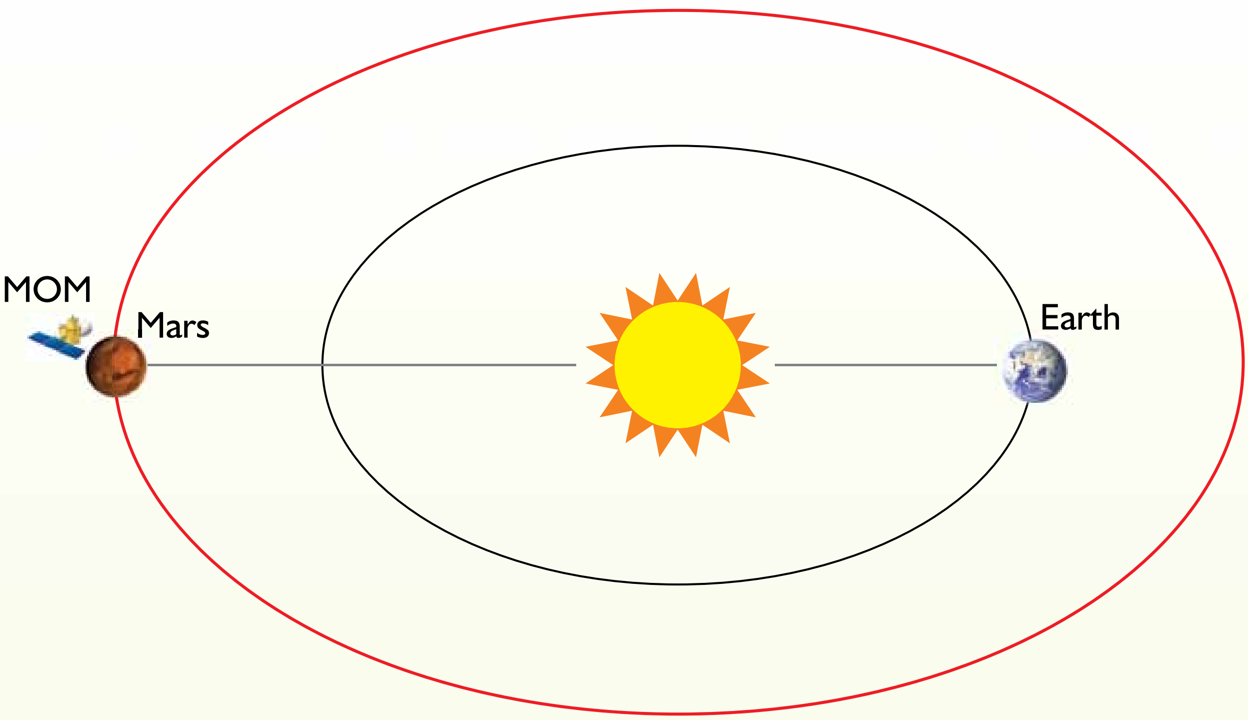
In February 2015, Mr Kunhikrishnan became Deputy Director of VSSC for Mechanisms, Vehicle Integration & Testing (MVIT) Entity. He is the recipient of Astronautical Society of India (ASI) award for the year 2011 and ISRO Individual Merit Award for the year 2010.

Mars Orbiter Spacecraft under 'solar conjunction' at Mars

Mars Orbiter Spacecraft (MOM) is under 'solar conjunction' at Mars, which means the spacecraft, which is orbiting Mars, is behind the Sun as viewed from the Earth. As a result of this event which happens once in 2.2 years for Mars, communication signals from the spacecraft are severely disrupted by the Sun's corona (outer atmosphere). The reason for this is the charged particles from the sun and they are responsible for the reception of noisy signals at the ground antenna from the spacecraft .

The conjunction for Mars Orbiter Spacecraft began on May 27, 2015 and will extend up to July 01, 2015. No commands are transmitted to the spacecraft during this period for safety reasons and only telemetry (spacecraft's health related information) is monitored. All payload (spacecraft's scientific instruments) operations are also suspended. Health of the spacecraft is normal.

Mars-solar conjunction



Continuing Medical Education (CME) on ISRO's Telemedicine network

Indian space programme has multi dimensions, providing significant infrastructure for national development in the vital areas like telecommunication, television broadcasting, meteorological observations and generating timely and accurate data on natural resources management. More recently, it has brought in revolutionary progress in education and public health domain. Today, the fruits of space research are reaching the common man and society, touching their daily life, be it a fisherman, a farmer, a student, a patient from a remote area, an administrator, a policy maker or a person struck in a natural disaster. In the recent years, ISRO has undertaken important applications programmes for societal benefits; one such example is being Telemedicine.

The telemedicine network of ISRO began in 2001 with a vision to extend technological support to provide quality medical services to needy patients across the country. In this pursuit, ISRO had provided dedicated satellite bandwidth, state-of-art satellite communication equipment, telemedicine hardware and software to various hospitals/medical colleges. The network is satellite based, with the central hub of the network located in Bengaluru.

The one-to-many Continuing Medical Education (CME) facility was introduced in the Telemedicine network by incorporating TrainNet, a Learning Management System (LMS). The TrainNet server is installed at the Telemedicine hub, Bengaluru. The Teacher Component of TrainNet has the capability to deliver the live audio/video of the presenter and power point presentation to all the receiving nodes. The lecture originating from one node can be received by all the nodes which have Student Component of TrainNet. Besides, the lecture originating node can have live audio-video interaction with remote student nodes, which is re-transmitted on the network, thus creating a 'Virtual Classroom'.

This facility will help hospitals and medical institutions to share their experiences and best practices with each other. As this is a satellite based network, any node on the network can be a lecture originating node after installation of Teacher Component.

CME session is conducted from Development and Educational Communication Unit (DECU)-ISRO, by inviting Ahmedabad based specialist doctors to DECU studio. Started in November 2014, around 2300 doctors/medical professionals from various hospitals and medical institutes have participated in the last 7 CME sessions. Live audio-video interaction was done between the specialist doctors in studio and the participants at remote locations. Around 130 questions were asked by various hospitals and medical colleges. In addition, medical cases were also discussed during the seven CME sessions. With this CME initiative, ISRO's Telemedicine programme has further improvised to benefit medical practitioners/doctors and is enhancing the utility of the network in service of the society. Eight such sessions of CME have been conducted so far.

ISRO Bags Padma Shri Awards

ISRO got two Padma Shri awards for the year 2014. Photos of the awardees receiving the award from The President, Shri Pranab Mukherjee are provided below:

Dr S K Shivakumar, Director ISAC, receiving Padma Shri

Shri S Arunan, Project Director, Mars Orbiter Mission, receiving Padma Shri

Space India is very proud and congratulates these awardees for their achievement

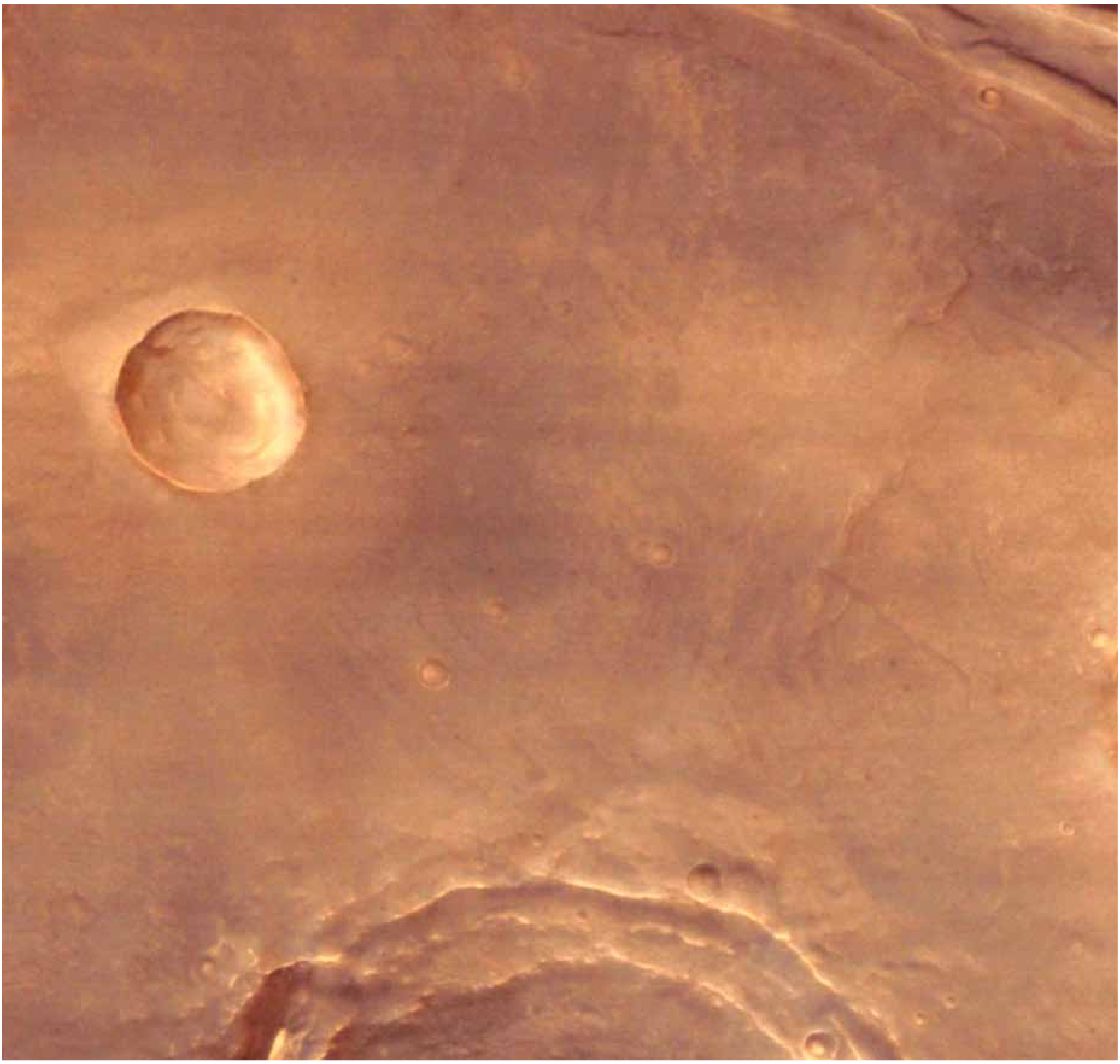


Image from Mars Colour Camera (MCC) on board MOM, taken on May 09, 2015 at 16:11:23UT at an altitude of 535 km and resolution ~25m. This is the last image taken before going into blackout mode. The image shows the area between Sinai and Lassell craters

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