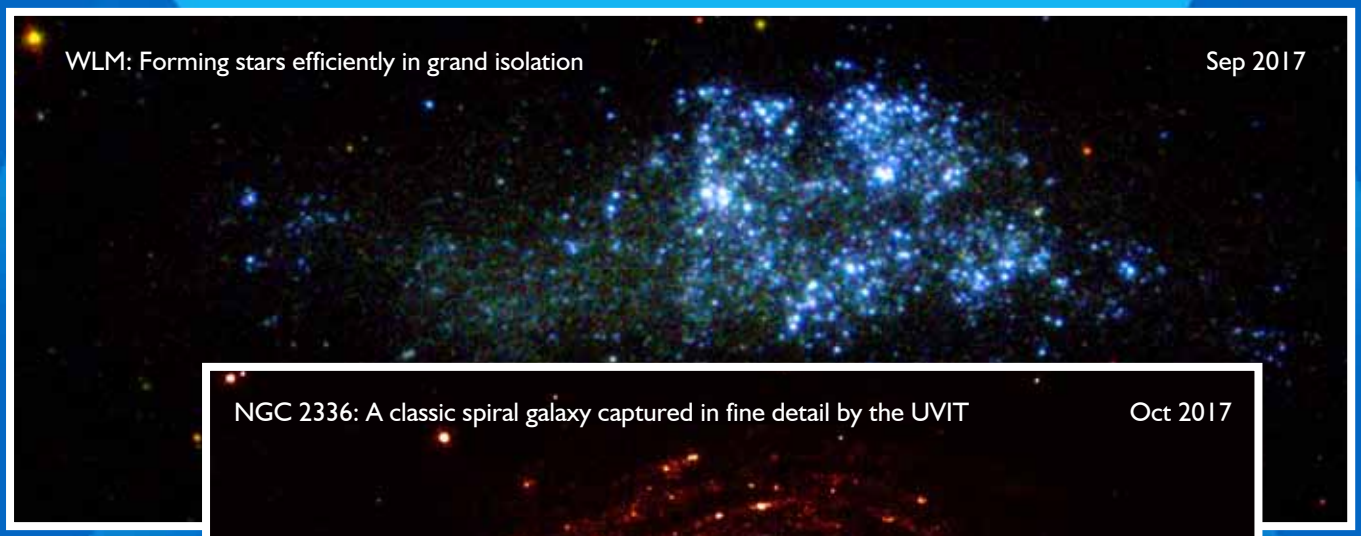
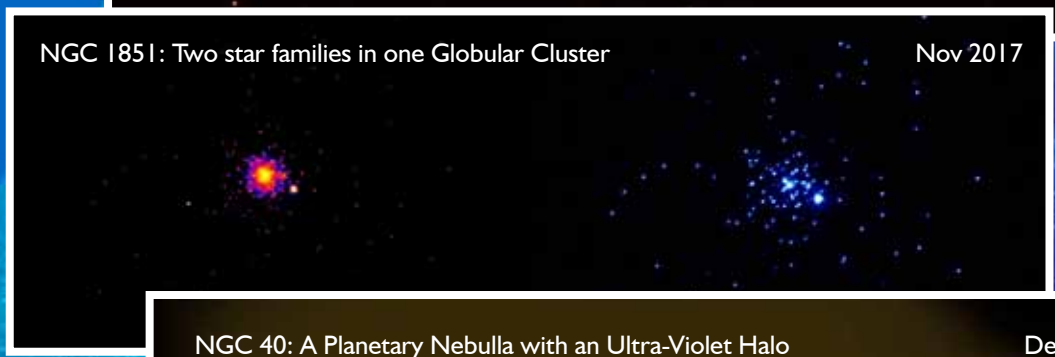
अन्तरिक्ष भारत SPACE INDIA

भारतीय अन्तरिक्ष अनुसंधान संगठन
Indian Space Research Organisation

जुलाई - दिसंबर 2017 July - December 2017

AstroSat Picture of the Month





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:

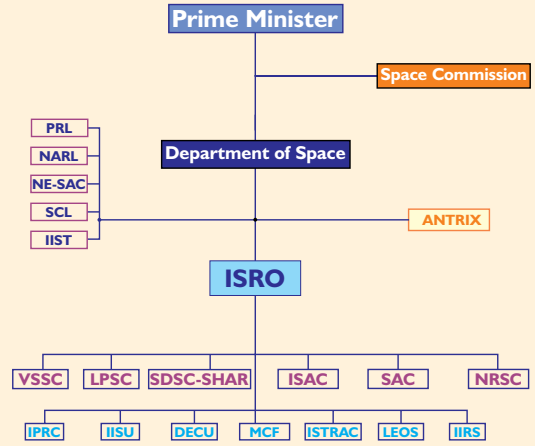
- Indian National Satellite (INSAT) programme for telecommunications, TV broadcasting, meteorology, developmental education, etc.
- Remote Sensing programme for the application of satellite imagery for various developmental purposes
- Indigenous capability for design and development of spacecraft and 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 programmes 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).

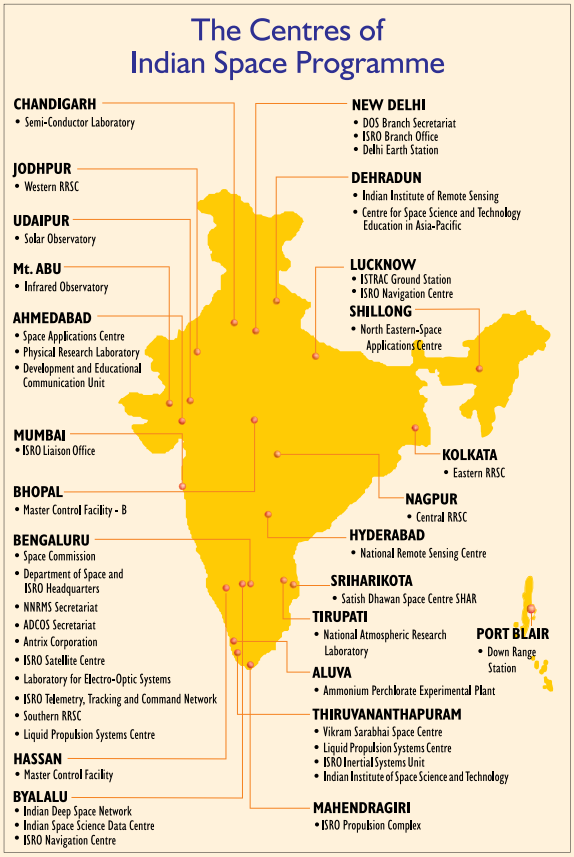
Antrix Corporation Limited, established in 1992 as a government owned company, markets space products and services.

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, 101 Indian Satellite Missions (including nine satellites by students and two nanosatellites) have been conducted. Two Re-entry Missions – SRE-1 and CARE module and 64 Launch Vehicle Missions (including RLV-TD & Scramjet-TD) from Sriharikota have been conducted.



PRL: Physical Research Laboratory **NARL:** National Atmospheric Research Laboratory **NE-SAC:** North Eastern Space Applications Centre **SCL:** Semi-Conductor Laboratory **IIST:** Indian Institute of Space Science and Technology **ISRO:** Indian Space Research Organisation **Antrix:** Antrix Corporation Limited **VSSC:** Vikram Sarabhai Space Centre **LPSC:** Liquid Propulsion Systems Centre **SDSC:** Satish Dhawan Space Centre **ISAC:** ISRO Satellite Centre **SAC:** Space Applications Centre **NRSC:** National Remote Sensing Centre **IPRC:** ISRO Propulsion Complex **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



अन्तरिक्ष भारत SPACE INDIA

भारतीय अन्तरिक्ष अनुसंधान संगठन
Indian Space Research Organisation

जुलाई - दिसंबर 2017 July - December 2017

Contents

Resourcesat-2A Completes One Year in Space	2
Silver Jubilee Journey of LEOS	4
International Seminar on ISP: 'Trends and Opportunities for Industry'	6
APRSAF-24 held in Bengaluru	8
ISRO Organises INTROMET-2017	10
38th Asian Conference on Remote Sensing	11
ISRO releases MOM Second Year Science Data	12
ISRO Celebrates World Space Week-2017	13
Successful Completion of one year of Service by SCATSAT-1 Scatterometer	17
Many Satellites Celebrated Birth Anniversary during last week of September	18
Operationalisation of Thunderstorm Nowcasting Services over NE Region Using DWR Data	19
NARL Studies Tropical Tropopause Aerosol Layer	21
Haze Removal Algorithm Developed for Cartosat Images	23
National Workshop on Popularisation of Remote Sensing Based Maps and GIS	24
ISRO Organises Outreach Programme in Hindi at Ranchi	26
PSLV-C39 Flight Carrying IRNSS-1H Navigation Satellite Unsuccessful	27
ISRO Develops Optical Imaging Detector Array for Hyperspectral Imaging Applications	28
Flood Monitoring using SCATSAT-1 Satellite	29
Indigenous Ship Bound Terminal Tracks PSLV-C38 Geo-spatial Information Trajectory Successfully	30
Outreach Facility at NRSC Inaugurated	31
A Tribute to Prof. U R Rao	32

Coverpage:
AstroSat Picture of the Month

Editors

Deviprasad Karnik
A S Padmavathy
B R Guruprasad

Editorial / Circulation Office
Publications & Public Relations Unit, ISRO Headquarters, Antariksh Bhavan, New BEL Road, Bengaluru - 560 094, India.
www.isro.gov.in Designed by Imagic Creatives, Bengaluru.

Resourcesat-2A Completes One Year in Space

India, with nearly 3.3 million sq.km. geographical area, is endowed with natural resources such as forests, crop lands, water resources, minerals, wetlands, snow and glaciers, etc. The accurate information on the availability of natural resources and their optimal management is vital for sustainable development and overall socio-economic growth of the country.

Resourcesat series of satellites, with a unique 3-tier imaging capability, have created their own 'niche' in catering to a multitude of applications, specifically in the area of land and water resources management. The first satellite of Resourcesat series, Resourcesat-1, was launched in the year 2003 followed by Resourcesat-2 in the year 2011.

Resourcesat-2A was launched in December 2016. It carries high-resolution LISS-4 sensor with 5.8 m spatial resolution and a five-day revisit capability; medium resolution LISS-3 sensor with 23.5 m spatial resolution and a coarse resolution AWiFS sensor with 56 m spatial resolution. All three payloads, the AWiFS, LISS-3 and LISS-4, are operated to acquire multi-resolution data over India and surroundings. Resourcesat-2A has been added to the fleet of Resourcesat series of satellites in order to deliver high quality images to generate consistent data products.

With Resourcesat-2 and Resourcesat-2A together in orbit, the revisit capability has improved to 2-3 days for AWiFS, 12-13 days for LISS-3 and 25-26 days for LISS-4. Combined revisits of Resourcesat-2 & 2A along with other satellites are useful in many ways for various applications.

Resourcesat-2A data products, namely, radiometrically corrected system level products, Geo referenced terrain corrected and Ortho-rectified products, were released for the user community from May 06, 2017 onwards after all the mission tests and calibration/ validation.

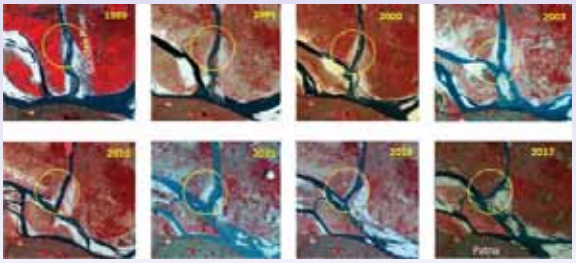
Resourcesat-2A provides continuity of data with higher temporal resolution (therefore more cloud-free data) for various operational applications, namely, crop production estimation, forest cover mapping, mapping and monitoring land & water resources, environmental applications, rural & urban development plans, geological applications, disaster management support, etc. The typical advantage of improved revisit as a consequence of Resourcesat-2 & 2A constellation is extremely useful for monitoring vegetation and water resources.

The inputs for operational programmes, such as Crop Monitoring, Horticultural crops assessment and development, Periodic water spread maps, Watershed Development projected care ensured with improved temporal resolution. New initiatives, such as, crop insurance, multi-crop inventory and near real time disaster management support, etc., are ably supported.

The growth of a typical annual crop (120 days) during kharif season can now be captured in 10 scenes instead of 4 to 5 scenes, thus improving the chances of getting cloud-free data as well as improving accuracy of estimation of area and productivity models. This helps in better selection of bio-window for vegetation studies. Improved revisit has helped in capturing the growing dynamics of vegetation as well as improves the probability of getting cloud free data.

Monitoring of crop parameters and biomass require high temporal resolution satellite data to capture changes in crop growth. The models with temporal algorithms could be applied in different themes. This would help in better crop discrimination and monitoring of minor crops, as they are predominantly cultivated with overlapping crop calendar. The phenology of forests can now be captured at better than fortnightly intervals. Using Resourcesat-2 & 2A LISS-3 data provides opportunity in rapid forest monitoring and its management and conservation of forest resources. This data shall also help in frequent monitoring of water bodies, especially with respect to water spread. Alluvial rivers in India deposit sand and suspended matter over time forcing rivers to change their course. Gandak River flows across the

floodplain of Bihar and merges with Ganga River near Patna. Remote sensing data of IRS series of satellites since 1989 along with Landsat provided unique observations on changing course of Gandak River near the confluence of Ganga during lean flow. The following Figure shows the changing course of river Ganga and Gandak near Patna, India.

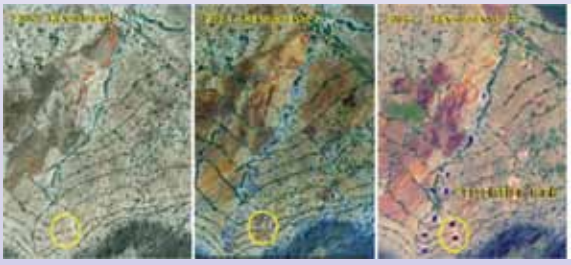


The Yearly Change in The River Course of Ganga and Gandak

Availability of LISS-4 data in about 25 days is making many new applications possible, namely, improved orchard inventory etc. Peri-urban horticulture mapping is another important application as it provides important input for price fluctuation/volatilisation issues.

With these data, now mapping of natural resources would see improvement in quality as more classes would emerge or could be better discriminated. Under Natural Resources Census (NRC) project, Resourcesat-2 & 2A LISS-3 data have been used in Land Use / Land Cover Change Mapping and Wastelands Change Analysis on 1:50,000 scale.

With respect to rural regions, the monitoring of Integrated Watershed Management Programme (IWMP) could be done more frequently than before as LISS-4 data along with Cartosat-1 data are used to monitor the changes in IWMP watersheds. About 8,200 such projects are to be monitored over a period of 5 years. About 2,000 LISS-4 products are needed annually for the study. 8,200 Projects are being monitored in the country and 2,500 scenes of Resourcesat-2 & 2A are being procured every year for the study. Example for Monitoring of Microwatershed in Prakasam Dist., of Andhra Pradesh is shown in the following.



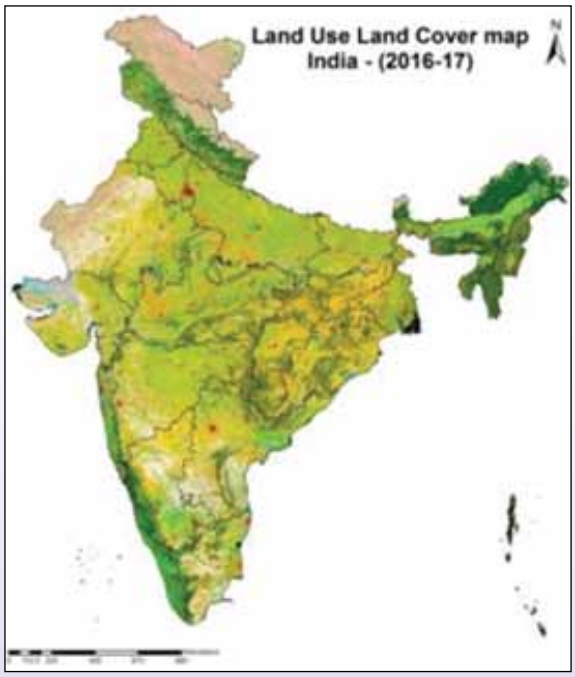
Microwatershed Monitoring Using Satellite Data

The improved availability of Resourcesat-2 & 2A data is useful for disaster monitoring, especially for events like flood mapping and monitoring at village level and damage assessment.

The specific advantage of having a constellation of Resourcesat-2 & 2A together provides the data at improved revisit capability, thus reducing the uncertainties in estimation of cotton crop or whatever the crop grown.

National Land Use / Land Cover mapping using multi-temporal 55 m spatial resolution satellite data was initiated in the year 2004-05 and 13 annual cycles of assessments have been completed till 2016-17 using Resourcesat-2 & 2A satellite data. This gives as unique ability to analyse decadal changes in land use and land cover and also to improve upon ground level practices for better natural resources management.

Thus, the Resourcesat-2 & 2A has added new dimensions towards improved use of remote sensing technology in the country.



National Land Use / Land Cover Mapping on 1:250,000 Scale

Silver Jubilee Journey of LEOS

The Laboratory for Electro-Optics Systems (LEOS), Bengaluru is one of the premier units of Indian Space Research Organisation (ISRO) under Department of Space (DOS). Since its constitution dated back to 1992 in Bangalore's industrial hub located at Peenya, LEOS has been associated with the design, development

LEOS at Peenya sheds 1992

and production of precise attitude sensors for all LEO, GEO and interplanetary missions along with the development and delivery of high-resolution optical systems for remote sensing and meteorological payloads. The humble journey that began 25 years back in industrial sheds of Peenya has evolved into a well-established laboratory that is equipped with world-class fabrication, testing and coating facilities. During this period (1992-2017), LEOS has primarily evolved into three major areas, namely, Sensor Development Area (SDA), Applied Optics Area (AOA) and Sensor Production Area (SPA) catering to increasing demands and needs of ISRO programmes.

The product portfolio of SDA encompasses a host of sun sensors from coarse to high accuracy, earth sensors, advanced star-trackers with arc-second accuracies, magnetometers, fiber optic gyro and guidance sensors.

AOA produces a variety of world-class optics relating to large field-of-view medium resolution refractive optical systems and moderate field-of-view high-resolution reflective optical systems, which have been successfully developed and delivered to Indian Remote Sensing Satellites missions. LEOS has mastered thin film technology required for enhancing reflectance and transmittance of mirrors and lenses from Ultra-Violet (UV) to Far Infra Red (FIR) wavelength regions. LEOS is in the forefront of developing advanced detector technologies required for realisation of attitude sensors and does comprise the state-of-the-art facilities for fabrication of Micro-Electro-Mechanical Systems (MEMS) based sensors and devices such as inertial grade accelerometers, RF switch, micro valve and micro heat pipes.

The SPA is carved exclusively with a focus on efficient production and capacity building of electro-optical sensors and optical systems using external/industrial manpower towards meeting a large number of sensors for various ISRO spacecraft.

A new building, named, 'Aryabhatta' has established and been dedicated exclusively for production with the state-of-the-art test facilities. In addition to

Aryabhatta Building

the defined core responsibilities, LEOS is further embarking on the development of advanced sensors and technologies in electro-optics field demanded by future space missions like sub-arc-second star-tracker, nano star-trackers, miniaturisation of sensors, optical communication terminals for high speed data transmission, high accuracy and precision magnetometer based on atomic system, advanced fiber optic sensors, high energy lasers, laser altimeter and LIBS/Raman spectrometer for planetary surface explorations, high precision rendezvous and proximity sensors for docking experiment, segmented optics, SiC based mirrors, diffractive optics based lens assemblies, MEMS gyroscope, MEMS atomic clock

physics package, antenna coupled μ-bolometer terra-hertz detector, SiC UV detector and super block absorber coatings using carbon nano-tubes.

LEOS celebrated Silver Jubilee on December 18, 2017 in its campus premises at Peenya, Bengaluru which was attended by Chairman, ISRO/Secretary, DOS, Founder Director of LEOS and all the former Directors of LEOS along with Senior Dignitaries of ISRO and all the serving LEOSians.

Chairman ISRO addressing during Sliver Jubilee Celebration

Chairman, ISRO acknowledged the importance of the services provided by LEOS in ISRO programmes, appreciated the laurels it has brought to space and socio-economic applications. He emphasised the need for innovations and to be the leader in this segment of technology. Former Directors and Senior Officials shared their reminiscences from the curtains of the past and reiterated the importance of growing

Honouring Dr. T.K. Alex, Founder Director of LEOS

further in tune to the need of the hour. All former LEOSians who retired from the service since 1992, were felicitated by Chairman, ISRO and Director, ISAC were honored by presenting a glass trophy symbolizing LEOS core responsibilities as a token of gratitude. A Compendium of Research Activities in LEOS was released by Chairman, ISRO, during this occasion.

International Seminar on ISP: 'Trends and Opportunities for Industry'

The International Seminar on Indian Space Programme (ISP): 'Trends and Opportunities for Industry' was organised by Indian Space Research Organisation (ISRO), and Antrix Corporation Limited in coordination with Federation of Indian Chambers

of Commerce and Industry (FICCI) at New Delhi during November 20-21, 2017. The objective of this two-day seminar was to deliberate on the best practices, pursue the ongoing discussion process to support further work of India's Space Sector and facilitate arriving at a coherent framework, wherein India's Space Sector can expand the domestic and global opportunities further, through enhanced partnerships and collaborations. The seminar highlighted the achievements and major milestones of Indian Space Programme in the recent past and discussed the future plans.

The Seminar was inaugurated by Shri AS Kiran Kumar, Secretary, Department of Space / Chairman, ISRO. In his inaugural address, he emphasised that the vision and objectives enunciated by Prime Minister Shri Narendra Modi, could be achieved, with progress in 'Make in India' and 'Start-up and Stand-up India' initiatives. He said the industry and stakeholders in the space sector value-chain could play a pivotal role in providing the necessary fillip to the advancement of country. He stressed that the value addition in the space sector is multi-faceted in its approach with collaborative models of development like Public Private Partnership (PPP) adding a new dimension to the future growth prospects. Shri AS Kiran Kumar urged the private sector to collaborate and explore the huge potential in space sector.

The President of Japan Aerospace Exploration Agency (JAXA) and Dy. Director General of Glavkosmos, Russia also gave special address during the inaugural session and reiterated their commitment to working with India in the space sector.

An Exhibition was also organised during the seminar, which was participated by several Space Industries and ISRO. The exhibition showcased ISRO's recent achievements in the area of Space Science and Technology. It also housed Five Kiosks with large screen display allocated to major centres of ISRO, demonstrating the offerings to the industry from the respective centre.

The FICCI Compendium on Indian Space Industry was released during the inaugural session.

The two-day seminar included sessions on "Space Industry Ecosystem : Opportunities for Industry", "Sustainable Propulsion Systems and Space Vehicles for ISP", "Leveraging Public-Private Partnership in Indian Satellite Programme", "Capacity Building and Talent Management" and followed by Panel Discussions on –"Role of Industry in ISP" and "International Industrial Cooperation in Space". Each session was lead by the eminent personalities of

ISRO, Antrix, FICCI, NITI Aayog, IIT(B), MEA, BEL, L&T, HAL, MT Aerospace AG, Germany and JSC Glavkosmos, Russia, etc.

- Talk on - Perspective of ISRO's Programme over next decade, Experiences of Russian Space Ecosystem, Perspective of Indian Space Industry (Electronics Systems, Mechanical Systems), Perspective of Foreign Supply Chain, etc., were delivered during the session on "Space Industry Ecosystem: Opportunities for Industry".
- Deliberations on Propulsion and Related Technologies, Launch Vehicles and Related Technologies, Policy Perspectives etc., were made during the session on "Sustainable Propulsion Systems and Space Vehicles for ISP".
- Discussions on Satellites, Payloads and Related Technologies, Enhanced Engagement opportunities for Indian Space Electronics Industry, etc., were held during the session on "Leveraging Public-Private Partnership in Indian Satellite Programme".
- Capacity Building in Indian Space programme, in Space Applications, Evolving Roles of Academia in Space, Synergy between Industry and Academia - Experience of Singapore, etc., were discussed in the session on "Capacity Building and Talent Management".
- The Panel Discussion on Role of Industry in Indian Space Programme was led by CMD, Antrix Corporation Ltd., with the Panel comprising speakers from various industries from ISRO and from FICCI.
- Panel Discussion on International Industrial Cooperation in Space was Moderated by Honorary Advisor, Space Division, FICCI with Panelists from Japan, Singapore, Russia, Thailand and USA.

Each Session concluded with a Closing Remark by the Session Chair and Distribution of Green Certificates.

While giving his valedictory address, Foreign Secretary, Dr. S Jaishankar said that India is proud of its space sector achievements. He mentioned that the space sector has come of age with rapid strides in PSLV, GSLV and GSLV-Mk III and having potential in economic growth and development of the country. He said that Industry, Government and Entrepreneurs have to work in tandem to realise the Prime Minister

Shri Narendra Modi's vision of 'Leaving no space between Common Man and Space'. He said The endeavour should be for holistic development of common man, so that the advantages of Space development reach the last mile. He said that the recent launch of South Asia Satellite is a matter of pride and reflects "neighbourhood first" policy of India.

The seminar provided a platform to deliberate and brainstorm on various multi-dimensional aspects of space collaboration among various stakeholders. The event saw the participation of key players from ISRO, the Indian Space Industry, Department of Industrial Policy and Promotion (DIPP) and International Agencies from Japan, Russia, Singapore, USA, Germany, France and Thailand. The stakeholders from industry, policy makers, thought leaders and academia, held discussions on the enabling and encouraging policies of Government of India to exploit the commercial space segment by Indian Industry targeting both domestic and international market.

APRSAF-24 held in Bengaluru

The 24th session of the Asia-Pacific Regional Space Agency Forum (APRSAF-24) was organised at Bengaluru, India during November 14 -17, 2017. APRSAF-24 was co-organised by the Department of Space (DOS) / Indian Space Research Organisation (ISRO), the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT) and the Japan Aerospace Exploration Agency (JAXA) with the theme "Space Technology for Enhanced Governance and Development". Shri A S Kiran Kumar, Chairman, ISRO/ Secretary, DOS and Ms. Mami Oyama, Deputy Director General, MEXT were the General Co-Chairs of this APRSAF-24 session.

APRSAF annual meetings are open fora for those who have interest in cooperation in the field of space activities in the Asia-Pacific region and are organised under four working groups namely, 'Space Applications', 'Space Technology', 'Space Environment Utilisation' and 'Space Education'. The recent achievements and future plans of each country and region were deliberated in these four working groups. The working group meetings were held during November 14-15, 2017. The summaries of the working group deliberations were presented in the plenary sessions during November 16-17, 2017 including special sessions on specific themes, namely, 'Sustainable Development Goals', 'Space Policy' and 'Space Exploration'. There was also an evening session on 'Space for Future Society' on November 15, 2017. Associated events of the Working Groups, namely, 'Space Applications For Environment (SAFE) Workshop', Asian Beneficial Collaboration through Kibo Utilisation - 'Kibo ABC Workshop' and 'Workshop on Space Policy' were organised on November 13, 2017.

APRSAF annual meetings were preceded by Water Rocket Event and Poster Contest for school students, as a means of generating interests in space and nurturing their creativity and innovative thoughts. APRSAF-24 Water Rocket event was organised during November 11-12, 2017 with Water Rocket making workshop followed by launch competition. 56 students in the age group of 12-16 years from 11 Asia Pacific countries including India along with Colombia in South America actively participated in this event. An educator session was organised, in parallel, in which about 40 teachers and educators from Asia-Pacific countries exchanged views on teaching methods. In Water Rocket event, teams from Sri Lanka, Vietnam and Malaysia have secured the First, Second and Third places, respectively.

Group photo of students participating in APRSAF-24 water rocket event

APRSAF-24 Poster Contest was organised with the theme "United Through Space". Thirty-six posters were submitted by students in the age group of 8-11 years from 12 Asia Pacific Countries including India. There were five different awards in the Poster Contest event and the ISRO award was won by an Indonesian student.

An exhibition was also organised to provide an opportunity for the Indian and foreign Industries to showcase their technological capabilities. Nine Indian Industries and nine Foreign Industries set-up their stalls in the exhibition.

APRSAF-24 was different from earlier annual meetings in many ways. It had highest number of Heads of Space Agencies from Asia Pacific region and South Asian countries. Heads of Space Agency session to deliberate on space agencies' contribution towards achieving Sustainable Development Goals (SDGs) was organised for the first time with the participation of heads of nine space agencies in Asia Pacific region - India, Indonesia, Israel, Japan, Malaysia, Russia, South Korea, Thailand and Vietnam. Two Special sessions, one each on 'Space Policy' and 'Space Exploration' were organised for the first time during the main plenary day. As a host Nation, India has organised a special session on 'Space Technology for enhanced Governance and Development', wherein officials from user Ministries of Central and State Government have shared their experience on the utility of space technology inputs for planning, monitoring and decision making.

A 'Space Leaders Round-Table' was organised in the concluding session on November 17, 2017 to discuss on the joint statement.

Following are the major recommendations of the Working Groups:

- National space agencies in the Asia Pacific region to develop small/cube satellites collaboratively, as the data from these satellites could provide input to solve various common issues of the Asia Pacific region;
- To further promote educational activities, using space technology as a tool that will be beneficial for the human resource development of the next generation;
- Encourage and accelerate Kibo (in ISS) utilisation through feasibility studies in each country;
- To further promote space application including rice crop monitoring, global rainfall monitoring, fire hotspot, haze monitoring and disaster management, etc.

Brief of various sessions/events of APRSAF-24 are given below:

- Space agency heads from nine agencies presented on current activities and future possibilities/ expected contributions of space technology in resolving their National priority issues toward achieving the SDGs.
- Space policy experts from seven governments in the region shared their views on how their countries is evolving their space policy in response to their national requirements.
- Representatives from India, Japan, Korea, Russia and UAE presented their perspectives on space exploration including the utilization of International Space Station, development of Deep Space Gateways and reaching out to the Moon, Mars and beyond.
- Space agency representatives from 13 countries in the Asia Pacific region have presented achievements of their national space programme and background on national policies in the "Country Report" session.
- In 'Space for Future Society' session, the speakers have shared their ideas on how aerospace technology, such as solar power, Global Navigation Satellite System (GNSS), and remote sensing can contribute to future society.
- In the Space Cooperation in Asia Pacific session, representatives of seven international organisations shared their views on the current trends and way forward in enhancing space cooperation.
- Space Policy workshop was jointly organised by the University of Tokyo Graduate School of Public Policy, Japan and the National Institute of Advanced Studies (NIAS), India, to provide an overview of space policy perspectives in the Asia-Pacific region and to explore further possibilities for international cooperation in the region.
- SAFE (Space Applications For Environment) is to contribute to the solution to various environmental problems with space technology and many prototyping which is being carried out by Asia Pacific countries was reviewed.
- Kibo-ABC (Asian Beneficial Collaboration through Kibo Utilisation) workshop was organised to encourage countries in the Asia-Pacific region to use the Japanese Experiment Module (JEM). Kibo is a human space facility that provides unique research capabilities in the International Space Station (ISS).
- A Press meet was also organised on Nov 17, 2017, where all the Heads of Space Agencies participated and interacted with the media.

APRSAF-24 had more than 600 registrations from over 31 countries and seven international organisations. Over 50% of the participants were foreign nationals. In addition to the 9 Heads of Space Agencies, President of French National Space Agency (who is also President of International Astronautical Federation-IAF), Director, United Nations Office of Outer Space Affairs (UNOOSA), two Astronauts from Japan namely, Ms. Chiaki Mukai and Ms. Koichi Wakata, participated in APRSAF-24.

Partcipants of APRSAF-24

ISRO Organises INTROMET-2017

The International Tropical Meteorology Symposium (INTROMET-2017) was organised by the Indian Meteorological Society, Ahmedabad Chapter (IMS-A) and Space Applications Centre (SAC), ISRO, Ahmedabad during November 7 - 10, 2017. India has been one of the front-runners in the field of space based earth observation and weather monitoring. INSAT series of satellites are providing data over multitude domains; Kalpana-1 is the first dedicated meteorological satellite, INSAT-3DR along with INSAT-3D is providing 15 minutes temporal coverage and 3D information of the atmosphere through its imager & sounder in multiple channels. The Scatsat-1 carrying Ku-band scatterometer provides ocean surface winds. RISAT-1 based SAR provides crucial information regarding sea-ice displacement. Megha-Tropiques (SAPHIR, ROSA, SCARAB), SARAL (Ka-band Altimeter) and GNSS also provide complementary observations. The theme of the symposium was "Advances in Space-based Earth Observations and Services for Weather and Climate".

INTROMET-2017 was inaugurated on November 07, 2017 in the august presence of the Chief Guest, Shri A S Kiran Kumar, Chairman, ISRO & Secretary, DOS, GoI and the Guest of Honour, Dr. M Rajeevan, Secretary, MoES, GoI. The inaugural function was attended by many of the distinguished invitees from IMD, ICRS, IITM and IISc etc., INTROMET-2017 got its international flavor with the participation of about 25 foreign delegates from all over the world including eminent meteorologists from NASA. More than 500 National delegates attended the symposium, which included practicing meteorologists, academia, researchers, members of the industry and students from across the country.

Shri A S Kiran Kumar, Chairman, ISRO expressed his optimism for the deliberations during the four days to bring out the specific observational needs of the meteorological community across the globe which can be translated to the design and development of meaningful satellite payloads for critical applications.

Dignitaries releasing the Souvenir

The symposium comprised four plenary sessions with a total of 12 talks by distinguished speakers. "An overview of Indian Earth Science Program" by Dr. M Rajeevan, "Monsoon teleconnection with Arctic Ice Melt" by Emeritus Prof. T N Krishnamurti, Program Scientist, NASA-HQ and "Shri D R Sikka Memorial Lecture" by Prof. Sulochna Gadgil, Emeritus Prof. IISc were the attractions of the symposium. A special lecture on "The NASA Airborne Convective Processes Experiment (CPEX)" was also delivered by Dr. Ramesh R Kakar, Program Scientist, NASA-HQ.

The presentations during the symposium were organised in several parallel technical sessions under the themes - Advances in monsoon studies, Weather forecasting, Hydrometeorology, Air-sea interactions, Cloud and precipitation, Atmospheric process studies, Meteorological data archival and dissemination, Extreme events monitoring and forecasting, Tropical cyclones, Climate change, Emerging trends in retrieval of geophysical parameters, Air quality, Agro-meteorology, Ocean studies, Aerosol-cloud interaction and Special sessions on SCATSAT-1 and INSAT-3D/3DR. Young researchers from Jammu and Kashmir to Nagaland participated enthusiastically. A dedicated session was conducted for undergraduate students specially selected by IMS local chapters and sponsored by IMS to attend and present in the symposium.

The concluding session of the symposium was chaired by Director, SAC in a panel discussion involving eminent delegates on the theme of extreme events-observations, modelling and dissemination. There was a unanimous agreement on the need to spruce up the communication system for disaster information dissemination to the last mile in a user-friendly language and dialects for better actionable strategies on the ground.

The symposium provided an opportunity for weather and climate scientists to present their research, exchange ideas, explore prospects for collaboration and discuss on the current and futuristic aspects of space based weather and climate studies. Awards were distributed for best papers in students and young scientist categories. Students nominated by IMS local chapters were also awarded.

38th Asian Conference on Remote Sensing

The 38th Asian Conference on Remote Sensing (ACRS-2017) was organised during October 23-27, 2017 at New Delhi, jointly by Asian Association on Remote Sensing (AARS), Indian Society of Remote Sensing (ISRS) and Indian Society of Geomatics (ISG) and Co-hosted by ISRO. The theme of the Conference was "Space Applications: Touching Human Lives". ACRS-2017 is a forum to bring together students, researchers, scientists, engineers, policy makers, professionals and practitioners from developed and developing countries from and around Asia. The main aim of the conference is to share insights into the challenges and opportunities of Remote Sensing and geo-spatial technologies. The conference was inaugurated by Dr. Jitendra Singh, the Hon'ble Minister of State in the Prime Minister's Office, Department of Space, Department of Atomic Energy, Government of India. Shri A S Kiran Kumar, Chairman ISRO was the Guest of Honour.

In his address, Dr. Jitendra Singh recounted ISRO's efforts in initiating collaborative projects with Ministries and Government Departments for stronger utilisation of space-based tools for effective governance. He stressed the extended support of space technologies to neighbouring countries through the recently launched South Asia satellite. Dr. Jitendra Singh said that ISRO missions are capable to provide more accurate information not only on the Earth but also the neighbouring planets.

Dr. Jitendra Singh, the Hon'ble Minister of State PMO, addressing the gathering during the inaugural session

Utilisation of Space technology for common man is the main aim of the country's space missions. Shri A S Kiran Kumar in his address, emphasised the role of space technology for various national developmental imperatives in governance, societal benefits, climate change and disaster risk reduction & mitigation. He elucidated various applications, which are directly touching the lives of citizens like farmers, fishermen, students, decision makers, etc. He also inaugurated the technical exhibition after the inaugural session.

Presidents of AARS, ISRS and ISG shared their views on contributions of the respective societies, followed by Awards conferred to eminent personalities by these societies.

A total of 6 plenary sessions, 13 special sessions, 67 technical sessions and 6 poster sessions were organised during the conference. 670 research papers were presented in oral and poster sessions in various themes namely, Advance Image Processing & Data Analytics, Climate Change & its Impact, Cultural Heritage Documentation, Cal/Val of EO Sensors, Disaster & Risk Reduction, Agriculture & Soils, Forest & Environment, Group on Earth Observations Global Agricultural Monitoring Initiative: Asian Experience, Geosciences & Mineral Exploration, Health GIS, High Resolution Data Applications, AVIRIS-NG; Climate Change & its Regional Impacts for Nature & Human Activities in Asia, Geo-spatial Education: Methods & Modalities, Citizen Science: Methods & Applications, Online Platforms for Education & Outreach, Crop Productivity from EO Satellites, Agro-met Information from EO Satellites, Marine Geology & Coastal Studies, NISAR - NASA-ISRO Synthetic Aperture Radar, Night-time Lights Imaging & Applications, Ocean & Atmospheric Studies, Open Source Geo-spatial, SAR Polarimetry: Methods & Applications, Urban & Infrastructure Planning and Water Resources Management.

The Conference witnessed scientific presentations during plenary sessions. Very eminent speakers across the globe namely Prof. Dr. Deren Li (Professor, Wuhan University), China; Dr. Christian Heipke (President, ISPRS); Dr. A.S. Kiran Kumar (Chairman, Space Commission and Secretary, Department of Space, Government of India); Dr. Hsin-Chia Lin (Albert), NSPO, Taiwan; Dr. C. Silapathong, GISTDA, Thailand; Prof. G.Xingfa, RADI, China; Dr. M. Annadurai, ISRO, India; Dr. Shin-ichi (Takashima), Sobue, JAXA, Japan; Dr. C.D. Elvidge (NOAA, USA); Dr. P.A. Rosen, JPL/CIT, USA and Prof. M.V. Marek, GCRI-CAS, Czech Republic delivered the invited talks. Dr. K.Shivan, Director, VSSC delivered Vikram Sarabhai Memorial Lecture on India's Space Transportation System. ISG Millennium Lecture was delivered by Dr. Upendra Tripathy (ISA, India) on Solar Energy Prospects and ISA's emerging role in energy segment. The conference was also attended by many of the former Directors and pioneer scientists of ISRO.

A panel discussion was organised on the final day of the conference on "Strengthening Academic, Industry, Scientific Societies and Space Agencies Interface for Improving Human Lives". Experts from AARS, ISRS, ISRO and Indian industries provided their views on the topic. Active participation of the delegates made the session lively and interactive.

Inauguration of technical exhibition by Shri A S Kiran Kumar, Chairman, ISRO

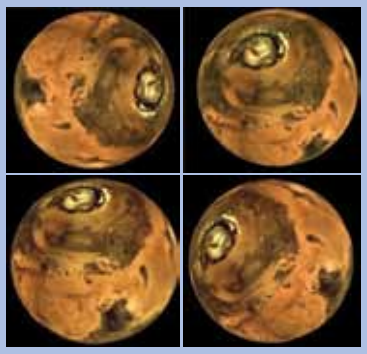
During the conference, a web contest was also organised and awarded the best web developer. Best paper awards were also given during concluding session. 32 Industries/Institutions exhibited their products and services related to geo-spatial technologies in the technical exhibition held during the conference. The conference was attended by more than 900 participants from 53 countries across the globe.

ISRO releases MOM Second Year Science Data

Mars Orbiter Mission (MOM), the maiden interplanetary mission of ISRO, launched on November 5, 2013, was successfully inserted into Martian orbit on September 24, 2014 in its first attempt. MOM completed three years on September 24, 2017, though the designed mission life of MOM was six months. The Spacecraft is in good health and continues to work as expected. Scientific analysis of the data, which is being received from the Mars Orbiter spacecraft, is in progress.

On the occasion of three years completion of MOM in Martian orbit on September 24, 2017, Space Science Programme Office, ISRO HQ organised a 'MOM Science Meet' on September 25, 2017. Presentation from five payload teams and twenty nine MOM-AO project teams were made during the Science Meet. About 100 participants attended in the Science Meet.

On the occasion of three year completion of MOM, second year data (Sep 24, 2015 to Sep 23, 2016) consisting of 492 data products was made available to the public through ISRO-ISSDC website https://mrbrowse.issdc.gov.in/MOMLTA.



ISRO Celebrates World Space Week-2017

World Space Week (WSW) is an international annual celebration of space science and technology, observed during the week of 04-10 October. The commencing and concluding dates of World Space Week recalls two important dates in space history.

October 04, 1957: Journey to space started with the launch of the first man-made Earth satellite, Sputnik 1.

October 10, 1967: The signing of the treaty on principles governing the activities of states in the exploration and peaceful uses of outer space, including Moon and other celestial bodies.

The Theme of WSW-17 is "Exploring New Worlds in Space"

WSW-2017 was celebrated across the country by various Centres of ISRO from October 04-10, 2017. The programmes were organised jointly by Vikram Sarabhai Space Centre (VSSC), Liquid Propulsion Systems Centre (LPSC), ISRO Inertial Systems Unit (IISU) and ISRO Propulsion Complex (IPRC) at Thiruvananthapuram, Kerala and Nagercoil, Tamilnadu. Satish Dhawan Space Centre (SHAR) has organised celebrations in 22 venues spanning 5 states, namely, Andhra Pradesh, Telangana, Tamilnadu, Odisha and Puducherry with a grand inauguration at Sriharikota by Hon'ble Vice President of India, Shri M Venkaiah Naidu. Vikram Sarabhai Space Exhibition (VSSE) at Space Applications Centre (SAC) also celebrated the event, which was witnessed by the people in and around Ahmedabad, Delhi, Rajasthan and Madhya Pradesh. Whereas, National Remote Sensing Centre (NRSC) along with its five Regional Centres (RC), had conducted WSW celebrations on a large scale by collaborating with the NE-SAC, State Remote Sensing Centres and Academia. ISRO Satellite Centre (ISAC) also celebrated the event by visiting two schools around Bengaluru.

Details of the celebrations are given in the following paragraphs:

WSW-2017 Celebrations at VSSC, LPSC, IISU and IPRC

The WSW-2017 was inaugurated by Honourable Chief Minister of Kerala Shri Pinarayi Vijayan on October 04, 2017 at Kanakakunnu Palace, Thiruvananthapuram. A Space Expo was organised at S.T. Hindu College, Nagercoil during October 5-9, 2017. The space expo showcased ISRO's achievements and contributions in space based technologies and applications. The exhibitions drew more than 1,00,000 people including students from more than 170 Government schools. Science students were trained and deployed as communicators for the exhibition. Career guidance and interactive sessions were conducted for students with lectures on variety of space related topics like space exploration, space technologies and applications etc. The open forum attracted space enthusiasts from various walks of life and provided opportunities for active discussions. Films related to space science were also screened at the venue. A special quiz zone was also set up exclusively for school students. The visitors could touch and feel actual engines and power heads used in ISROs work horse launch vehicles and satellites. Free bus services were provided to transport the students to the venue.

A workshop for students was organised in VSSC, Thiruvananthapuram on October 06, 2017 with the participation of around 370 students. The students were chosen from institutions in rural areas across the state including tribal schools and care centre for cancer patients. The initiative was aimed at creating interest and awareness among the students. Senior

Dr. K Sivan, Director, VSSC briefing exhibits to Shri N Suresh Rajan, MLA after inauguration at ST Hindu College, Nagercoil

scientists of ISRO interacted with the students and several interesting queries were raised and answered. Lecture session was also conducted on space science and technology.

Open Innovation Contest was organised for students of engineering colleges & science colleges in Kerala.

The three day long Open House featured visit to VSSC Space museum, sounding rocket launch pad and control centre. Open house drew more than 10,000 visitors. The public could see the location where ISRO's space programme took shape and where pioneers of Indian Rocketry forged their ideas. The visitors also witnessed sounding rocket launch at TERLS and visited the Space Museum.

Citizen's familiarisation programme were conducted in VSSC for 300 registered participants. The main objective was to provide scientific awareness, increase knowledge and understanding of the benefits from space. Resource materials on theme of WSW-2017, India's Mars Orbiter Mission and Astrosat mission were distributed for students and other participants.

WSW-2017 programme was broadcast in AIR, AIR FM Kumari and DD Malayalam channel. The programme included LIVE discussion panel about role of space as a most critical and indispensable infrastructure for the world. pre-recorded video on WSW theme and talks on space transportation systems, navigation systems, extra-terrestrial habitat, benefits of space programme, etc., were also broadcast.

WSW- 2017 events were concluded in a formal function held at VSSC on October 10, 2017.

WSW-2017 Celebrations at SHAR

Satish Dhawan Space Centre (SHAR), the Spaceport of India, celebrated the World Space Week through public outreach programmes spread across 22 venues. After the inauguration by Honorable Vice President of India, Shri M Venkaiah Naidu, SDSC SHAR teams moved out to other 21 venues with the exhibition materials conveying ISRO's achievements.

Exhibitions of scaled down models of launch vehicles and satellites, informative panel displays, video screening of ISRO Space activities, interactive lectures by senior executives of SDSC SHAR, competitions for students and "Space Awareness Walk" were organised in each venues, mainly to educate the students on space research activities and to hone the scientific inclination in them. Video wall displays were arranged in the schools including those in the rural areas. Sounding Rocket launches were also arranged at Sriharikota on four days during the week. Students and Public were offered the opportunity to visit the various facilities at the Spaceport of India on all the days during the week.

The hosting institution at each venue was chosen considering the approachability to public, availability of large exhibition hall to showcase the exhibits, availability of video screening halls and infrastructure to accommodate a multitude of students participating. Inauguration and valedictory functions were organised

Inauguration of Space Week Celebrations at Sriharikota by Hon'ble Vice President of India, Shri M Venkaiah Naidu

at all the venues jointly with the hosting institution and local state government authorities, graced by important dignitaries / eminent personalities.

WSW-2017 Celebrations at SAC

The celebration of WSW-2017 by SAC was witnessed by a large number of Space enthusiasts; more than 15,000 visitors of all age-groups and various sections of society participated in the event. Various competitions such as Paper model making, Coloring/Drawing, Water Rocket Launching, Space Quiz, Elocution, Presentations, etc., were organised for students and specially-abled people wherein all participants were given a certificate and Do-It-Yourself GSLV-MkII model.

Many posters were designed to explain the WSW theme. 3D movies on various missions of ISRO and Images obtained from various satellites like Cartosat, MOM and Resourcesat were displayed on a large screen throughout the day and night. A live display of INSAT-3D imager was also organised. Mobile Planetarium shows were run throughout the day for kids and visitors.

Talks by eminent speakers were arranged and visitors got an opportunity to interact with eminent scientists throughout the day and got their queries answered and their curiosity satisfied.

The highlight of the week was sky observation using telescope. Four telescopes (11", 8", 5" and 3") were used to show Moon, Saturn, Venus, Mars, Orion Nebula, Pleiades, Sirius, Vega, Altair, Antares, Lyre, Double Stars etc. Thousands of people queued up enthusiastically for hours late in the night and early mornings to observe these spectacular objects in the sky.

WSW-2017 Celebrations at NRSC

WSW-2017 celebrations at NRSC included promotional activities focused on campaigning about ISRO's Space Programme and its contributions to the nation benefiting citizens, various applications of Remote Sensing (RS) data, support in disaster management and monitoring climate change, etc.,

Exhibitions of various miniaturised models of Launch Vehicles and Satellites of ISRO were arranged. Live demos of BHUVAN Portal was organised and interaction with Antarctica scientists to the students at the exhibitions were also arranged. Satellite/Aerial data Fly through demos of Hyderabad City, Mumbai City, Himalayas, including Kedarnath, etc., were made for providing a deep insight into RS capabilities. Satellite Images and Aerial Data, pertaining to RS Applications were displayed. Audio-visual programmes showcasing ISRO activities, Satellite Launches, Interactive sessions with scientists at Balanagar, Jeedimetla and Shadnagar campuses were organised.

Scientists delivered lectures at various schools in and around Hyderabad and Rangareddy districts especially focusing on the underprivileged students. Study material on ISRO Space Programmes and applications of Remote Sensing were provided to all the schools throughout the country using e-media like ftp, Internet from RCs and State Centres.

Across India, celebrations were conducted in the States / Union Territories of Arunachal Pradesh, Assam, Manipur, Nagaland, Meghalaya, Sikkim, Bihar, Jharkhand, Uttarakhand, J & K, Haryana, Punjab, Rajasthan, Madhya Pradesh, Chhattisgarh, Karnataka, Tamil Nadu, Kerala, Andhra Pradesh, Telangana, Goa, Maharashtra, Delhi, Chandigarh and Diu & Daman.

Quiz programmes for students were organised at various states. A total of 18 teams, which are toppers at their respective state levels have participated in the National Quiz held at Earth Station, Shadnagar. Assam

Team participated through Video Conference at NE-SAC. 75 students visited Shadnagar to participate in the Quiz finals.

As part of painting competitions, 50 paintings were received. 50 Teachers from all parts of the country came to Shadnagar and took part in the concluding sessions of the celebrations. Live demonstration of Satellite data acquisition was witnessed by the participating students.

ISRO deputed two scientists of NRSC to Nigeria on invitation from Nigerian Government for participation in World Space Week Celebrations Organised by Nigeria Erosion & Watershed Management Project (NEWMAP).

Shri A S Kiran Kumar, Secretary, DOS & Chairman, ISRO had participated in the valedictory function through Video Conference from New Delhi and addressed the students participating in the function and 1,80,000 plus students from nearly 3600 schools of Telengana state through the live telecast.

The exhibitions had overwhelming response from the students of various schools. Overall, 4,19,536 students/general public across the country participated in the celebrations of WSW-2017 organised by State Remote Sensing centres, Regional centres of NRSC, NE-SAC, Professional Societies and NRSC, Hyderabad and viewers through TV network.

WSW-2017 Celebrations at ISAC

A group of Engineers and Technicians of ISAC visited two schools in the outskirts of Bengaluru and acquainted the school children with the working of satellites and launch vehicles besides briefing them about the Indian Space Programme, its pioneers, number and types of satellites/launch vehicles launched so far, their applications and benefit to society and country besides future plans of ISRO. Posters and stickers were distributed to the students and schools were presented with a scaled model of spacecraft for their science laboratory.

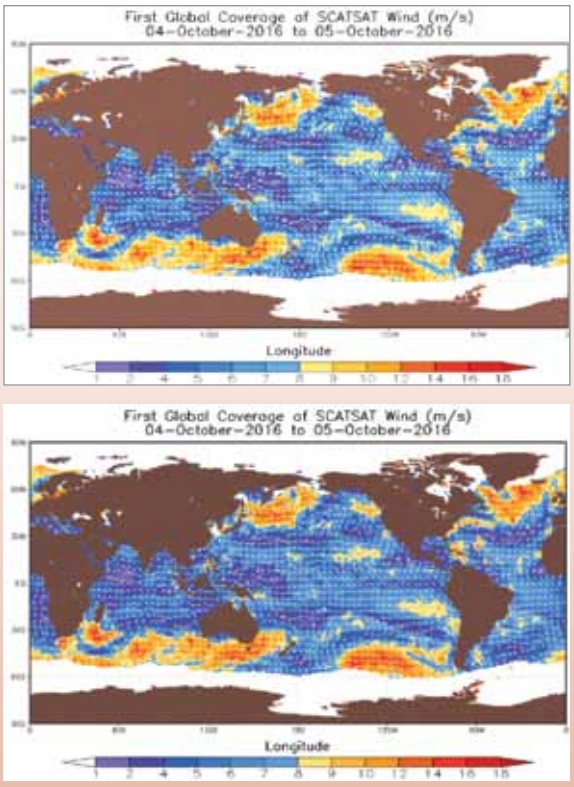
A team visited the Government Primary/High School at Araleri, Malur Taluk, Kolar District on October 06, 2017 and explained the significance of World Space Week to children. Different types of Spacecraft and rockets launched by ISRO, their subsystems, construction materials, orbits, mission manoeuvres, facilities at ISAC, space environment and different tests carried out on spacecraft, etc., were explained in local language followed by a question and answer session. As a motivational aspect the children were informed about the career prospects in ISRO / DOS and what it takes to enter ISRO / DOS. A brief about how space technology is being leveraged for societal / national development was made. The principles on which the satellites and launch vehicles work were also explained. The future ISRO plans were also touched upon in the end. Demonstration of a launch vehicle model formed part of the briefing. Nearly 150 students and staff members participated in the event.

Another team visited the Devasandra Govt. High School near Harohalli in Kanakapura Road on October 07, 2017 and briefed nearly 250 students on the topics mentioned above.

ISRO succeeded in conducting the World Space Week celebrations as one of the biggest and popular outreach programmes of the Organisation. Important task of this programme was to inform the public about the latest advances and discoveries in the space field, application of space technologies in daily lives and to develop programmes to inspire young people to pursue careers in science and technology. In summary, through WSW-2017 events, ISRO could reach out to all the major cross sections of society, made them aware of space technologies and inspired children to learn. The entire programme was very well received. The interaction with students was a great success with teachers expressing their appreciation. The exhibition and video show fascinated everyone. World Space Week activities received broad coverage by print and electronic media also.

Successful Completion of one year of Service by SCATSAT-1 Scatterometer

SCATSAT-1, the state-of-the-art satellite with a dedicated Scatterometer payload was launched on September 26, 2016. It is a continuity mission for Oceansat-2 Scatterometer (OSCAT) to provide wind vector data products for weather forecasting, cyclone detection and tracking services to the users. SCATSAT-1 inherits the design of OSCAT, hence operates in Ku-band having 13.53GHz central frequency and having a pencil beam design with two beams with incidence angles of 490 and 570 on ground with HH and VV polarization respectively. With a swath width of 1800 km, this instrument covers 90% of the earth's surface in a single day. With the experience gained through OSCAT, a few improvements have been made to the sensor characteristics for better sensitivity in backscatter, especially in Polar Regions.



Global Ocean Surface winds (m/s)from SCATSAT-1 during October 04- 05, 2016 (Top) and October 01- 02, 2017 (Bottom)

The radar backscatter measurement of SCATSAT-1 has commenced with the switch-on of main TWTA (Traveling Wave Tube Amplifier) on October 03, 2016. The instrument had undergone calibration and validation (Cal-Val) phase during which sensor stability monitoring, fine-tuning of algorithms took place. As the sensor is providing very high quality observations without any glitch, which provided good confidence on the instrument performance and led to the early public release of wind products (Beta version) through MOSDAC and NRSC as a Beta version on October 22, 2016. Subsequently after successful completion of the Cal-Val phase, the mission entered into operational phase from April 21, 2017.

The main operational products from this mission are global ocean surface wind products at 25 km and 50 km swath grids. Apart from this, various value added products such as (1) High Resolution Winds at 6.25 km swath grid (2) Daily Analysed Winds and (3) High Resolution Sigma0 products over land and polar regions, are routinely generated and disseminated to the user community through MOSDAC.

SCATSAT-1 provided invaluable wind observations during various cyclones such as, Matthew, Hima, Nina, Nada, Vardha, Maarutha, Moora, Harvey Irma, etc., Apart from this, the SCATSAT-1 wind products are able to cater to various applications like - improved weather forecast through data assimilation in NWP models, improved Cyclone track and intensity prediction, improved ocean state forecast through SCATSAT-1 derived wind forcing. SCATSAT-1 derived ocean surface winds are being operationally assimilated by National Centre of Medium Range Weather Forecasting (NCMRWF), MoES and Space Applications Centre, ISRO in Numerical Atmospheric Weather Prediction Models to improve the predictions. Moreover, using the SCATSAT-1

measured backscatter data, land applications like soil moisture estimation and hydrological applications such as, river water level change detection studies, etc., and polar studies of studying the spatio-temporal variability of Ice coverage, are well demonstrated.

Analysis of SCATSAT-1 super resolution data derived sea ice had revealed that the seasonal minima of the Antarctic sea ice (occurred in the first week of March 2017) and the seasonal maxima (occurred on September 15, 2017) were delayed with respect to 2016. An animation was prepared from sea ice images from January to September 15, 2017. The sea ice derived from SCATSAT-1 was studied with respect to the median value of sea ice extent from 1978 to 2010. The climatological sea ice behaviour shows that this year the sea ice remained below normal (1981- 2010 median value) for all the months.

The SCATSAT-1 data is extensively used on daily basis by both National as well as International users. It provided valuable input data to the global community in the area of weather forecasting and cyclone detection & tracking.

Many Satellites Celebrated Birth Anniversary during last week of September

Mars Orbiter Mission (MOM), the maiden interplanetary mission of ISRO, launched on November 5, 2013, was successfully inserted into Martian orbit on September 24, 2014 in its first attempt. MOM completed three years orbiting around the Planet Mars as on September 24, 2017.

- On this occasion, Space Science Programme Office, ISRO HQ conducted a 'MOM Science Meet' on September 25, 2017.

The first dedicated Indian Astronomy mission, AstroSat, also completed two years in orbit on September 28, 2017.

- In order to commemorate two years completion of AstroSat in orbit, Space Science Programme Office (SSPO), ISRO Headquarters organised an "AstroSat Science Meet" at ISRO HQ, Bangalore during 26-27 September 2017.
- AstroSat successfully completed 10,000th Orbit on Aug 03, 2017 at 23:49 Hrs (IST) and had observed more than 360 celestial sources.
- A Poster "AstroSat Picture of the month - September 2017" was also released on this occasion.

SCATSAT-1 completed one year in orbit on September 26, 2017. It was launched on September 26, 2016 on-board PSLV-C35. SCATSAT-1 is a continuity mission for Oceansat-2 Scatterometer to provide wind vector data products for weather, forecasting, cyclone detection and tracking services to the users.

- It has provided valuable input in the area of weather forecasting and cyclone detection & tracking to the National as well as International users. The SCATSAT-1 data is extensively used on daily basis with the usage touching about 85,000 downloads per month from NRSC web portal.

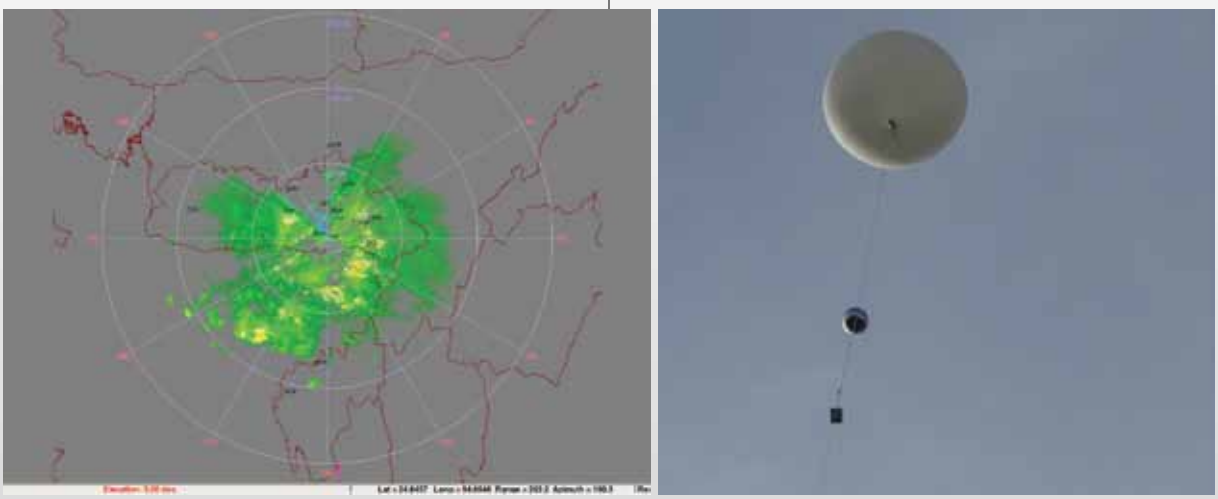
All these Satellites are in good health and continue to work as expected. Analysis of the data received from these satellites is in progress.

Other Satellites launched during Last Week of September are GSAT-10 on Sep 29, 2012, Oceansat-2 on Sep 23, 2009, INSAT-3E on Sep 28, 2003 and IRS-1D on Sep 29, 1997.

Operationalisation of Thunderstorm Nowcasting Services over NE Region Using DWR Data

North Eastern-Space Applications Centre (NE-SAC) has been providing thunderstorm nowcasting (forecasting upto 4 hours) services for North Eastern Region (NER) of India since 2015 under the North Eastern Regional node for Disaster Risk Reduction (NER-DRR) initiatives. This was done using the data from satellite images and sounder onboard INSAT-3D / INSAT-3DR, automatic weather station data, and by analysing numerical weather forecast data. However, it was difficult to detect, track and forecast using this data alone as most of the thunderstorms being localised events, extending only over a few tens of km and having a lifetime of less than one hour. The availability of DWR data has opened a new window for precise identification of thunderstorm weather systems, track them and forecast the probable areas which may get affected, albeit with lesser lead time.

The first S-band dual polarimetric Doppler Weather Radar (DWR) was installed at Cherrapunjee, Meghalaya which was dedicated to the nation by Shri Narendra Modi, Hon'ble Prime Minister of India on May 27, 2016. NE-SAC is operating the DWR continuously since then, and the data is made available in near real time for public through the MOSDAC (Meteorological and Oceanographic data archival centre) and IMD websites. The DWR is calibrated at regular intervals and the data products are being validated. It has unobstructed coverage for the entire state of Meghalaya, Tripura, Southern Assam, and part of Mizoram and Manipur. For the western and central Assam region, the DWR has coverage beyond three degree elevation only. The DWR also sees large part of India's neighboring country, Bangladesh. The radar completes one volume scan in 11 minutes, comprising of 360 degree azimuth scan for 10 elevation angles ranging from 0.5 to 21 degrees. It also allows sector scan (in both azimuth and elevation) for high temporal observation of any event. The DWR covers a distance of 250 km (up to 500 km only for Z) with a spatial resolution of 300 m.

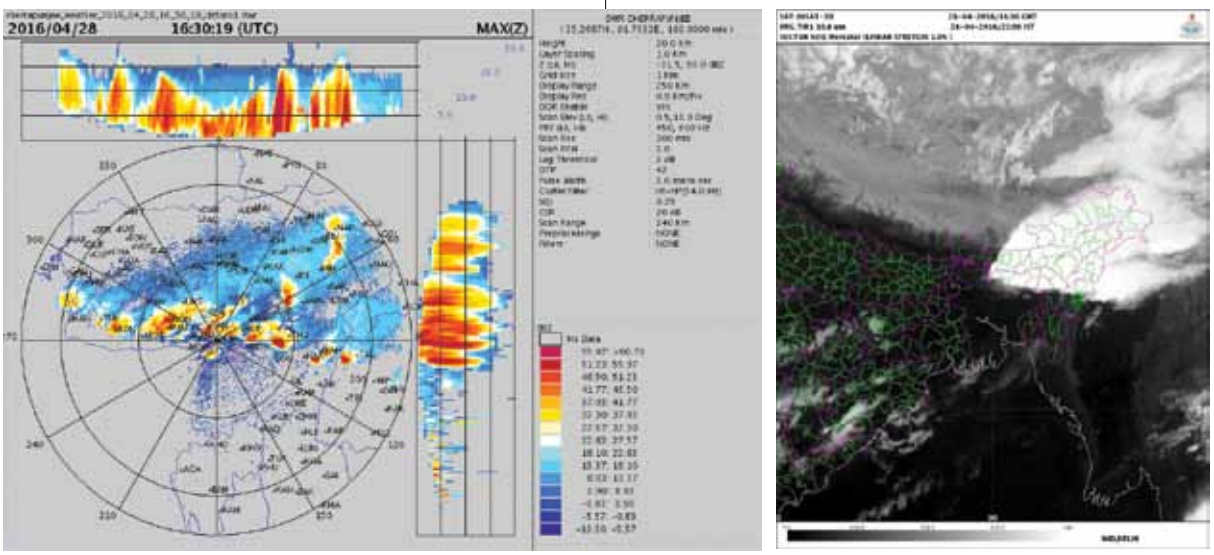


The DWR, Cherrapunjee coverage for elevation angle of 3 degree (left). Calibration of the DWR using metal sphere attached to hydrogen gas filled balloon & Pisharoty sonde (right)

Thunderstorm is a pre-monsoon season (April-May) phenomenon over the NER of India. The data collected by the DWR during 2016 was used to understand the thunderstorm and storm signatures and calibrate the nowcasting model. During 2017, nowcasting service was made operational. Severe thunderstorm nowcasting services for Southern Assam, Meghalaya and Tripura were done primarily using the DWR data and for the rest of the NER, the earlier methodology was used. In addition to the Z (radar reflectivity), S (spectral width) and V (velocity) data collected by the DWR, extensive use of the polarimetric data like ZDR (differential reflectivity) and HV (Correlation coefficient) were also made to differentiate thunderstorm clouds from non-thunderstorm clouds.

Almost all the thunderstorms affecting Meghalaya, southern Assam, and Tripura could be identified using the data from Cherrapunjee DWR during the pre-monsoon season of 2017. The spectral width (S) data was used to characterise the internal turbulence within a cloud system that helped in quantifying the storm potential (S>5) of a particular cloud. Hail potential could also be identified using ZDR (ranging from 0.5 to - 0.5) and HV (~0.9) data. The radar reflectivity, Z and its vertical profile (Max Z plots) was the backbone of thunderstorm identification and identification of individual storm cells in large cloud bands that appear in satellite images. All clouds having Z value more than 40 dBZ could become a thunder cloud and were tracked in real time. Z of 50-56 dBZ was categorised as severe thunderstorm and Z of more than 56 dBZ was categorised as very severe thunderstorm with hail. The reflectivity and velocity of clouds were studied to track every individual storm and forecast the likely affected areas within certain time intervals, based on sustenance potential of such storms, estimated by analysing the local atmospheric condition.

The use of the Cherrapunjee DWR data has improved the thunderstorm nowcasting accuracy over Meghalaya, Southern Assam, and Tripura states. Altogether 48 severe and very severe thunderstorms were forecast in these three states during April 1 to June 15, 2017 period. The accuracy of nowcasting was more than 90% with lead time varying from 30 minutes to more than 2 hours. The nowcasting services were disseminated through NER-DRR website and also through direct communication to the concerned at state level.



A squall line formed over Meghalaya, Southern Assam, and Manipur which is clearly identified using DWR data (left). INSAT-3D TIR1 channel image of the same time is also shown (right). The DWR data helped in identifying the individual storm cloud cells in a large cloud band as seen in satellite image

NARL Studies Tropical Tropopause Aerosol Layer

Aerosols, Radiation and Trace Gases Group (ARTG) of National Atmospheric Research Laboratory is engaged in studying atmospheric aerosols, trace gases, radiations, clouds and their interactions. Aerosols, the sub-micron size particles suspended in air are produced from a variety of man-made as well as natural processes such as vehicle exhaust, waste-burning, wind blown dust, volcanic eruptions, etc. These aerosols are mostly restricted to the first few kilometers from the surface of Earth's atmosphere. It is natural to detect them in the Upper Troposphere and Lower Stratosphere (UTLS) only during episodes like volcanic eruptions.

However, recently an intense aerosol layer persisting at the tropical tropopause altitude (~16-17km) over South Asia is discovered in the satellite observations. They are perceived to be result of increased pollutant gases and aerosols reaching UTLS altitudes due to strong convective activity over this region during summer months. These pollutants on entering stratosphere reside there for long duration and can affect the Earth's energy budget, stratospheric ozone through heterogeneous chemistry and the formation of cirrus clouds, thereby having climate impact. Observed increasing pollution trends is a matter of concern as these trace gases and aerosols could affect ozone in the lower stratosphere and modulate radiative properties of cirrus clouds. To date, no attempt has been made to prove it as a aerosol layer due to its complicity in nature.

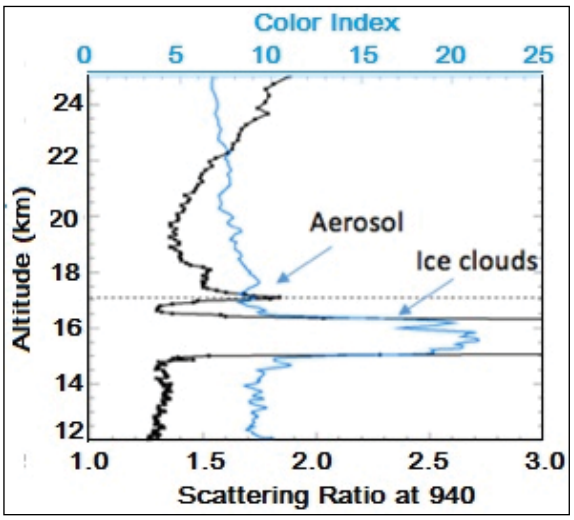
Zero Pressure flight launched on Aug 21-22, 2017 from TIFR balloon facility, Hyderabad

In order to ascertain this as aerosol layer, Scientists from University of Wyoming and Science Systems and Applications Inc., NASA from USA, in collaboration with NARL carried out balloon borne in-situ measurements of Asian Tropopause Aerosol Layer (ATAL) since 2014. Under an Implementing Arrangement between NASA and ISRO, in-situ measurement campaign to characterise the ATAL in UTLS region was carried out in July-August 2017. A series of balloon field campaigns were carried out during the Asian Summer Monsoon to understand the nature, formation and impacts of the ATAL better.

The overall campaign comprised of six small balloon launches to measure ozone, water vapor and aerosol from NARL, Gadanki, and 9 medium to big balloon launches from TIFR balloon facility, Hyderabad. Several ground based instruments like MST radar, Mie Lidar, surface aerosol and trace gas instruments are being operated from Gadanki during the campaign period. Among the instruments flown on balloons are COBALD (Compact Optical Backscatter Aerosol Detector), CFH (Cryogenic Frost point Hygrometer), Ozonesonde, Optical Particle Counter (OPC), and Impactor / Filter. OPC and Impactor are relatively heavy instruments which require plastic balloons. Payload weight ranged from 2 kgs to 30 kgs with the overall weight as high as 80 kgs. All the payloads were

recovered with 100% success rate. Particle sampling using Impactor with controlled ascent rate is the highlight of this campaign.

These measurements confirmed the presence of aerosol layer seen in satellite measurements over Asian region as shown in the figure. Sharp increase of aerosol concentration ($r > 0.075$ micron) near 16.5-18.5 km is observed. This layer has distinct size distribution as opposed to that from background mineral aerosol dust that is naturally present in the atmosphere. This layer contains particles of size less than 0.25 micron and are 90% volatile. It appears the aerosol is formed from precursor pollutant gases in the UTLS region which are transported via convection from the ground. The layer is strongly correlated with cold point tropopause and influenced by convective moisture indicating meso-scale convective systems role in transport of pollutant gases and moisture to UTLS region.



Profile of scattering ratio at 940 nm and Color Index (Source: Jean-Paul Vernier/SSAI-NASA Langley)

Preliminary chemical analysis of samples collected in this campaign indicates the dominant presence of nitrate, which is a new finding. Converging air masses over northern part of India, particularly centered around head Bay of Bengal during Asian Monsoon which is generally active during July – August months is found to be the main forcing for vertical transport of the aerosols and trace gases to the UTLS region along with long-range transport from northern parts of India.

However, detailed analysis yet to be carried out with all the data collected during the campaign. One additional campaign during winter months for obtaining the background conditions is planned. Presence of different pollutants which results from interplay of different circulation patterns and pollutant source regions also necessitates multiple campaigns spread over a few years (until 2020) to comprehensively characterise the aerosol layer in the UTLS region and study its impact on radiation budget and ozone chemistry. Additionally, this campaign seeks to use balloon-borne measurements of aerosol, water vapor, and ozone to validate measurements from NASA's Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite and NASA's Stratospheric Aerosol and Gas Experiment (SAGE) III instrument along with Cloud-Aerosol Transport System (CATS) on the International Space Station.

Haze Removal Algorithm Developed for Cartosat Images

High resolution optical imaging Earth Observation Satellite (EOS) systems such as Cartosat provide multi-spectral remote sensing data in the Visible and Near-Infrared (VNIR) wavelengths of the order of sub-meter to few-meters. These datasets can be used in a variety of applications, particularly associated with precise mapping, monitoring and change detection of earth's surface, if Top Of the Atmosphere (TOA) measurements can be properly compensated for atmospheric absorption and scattering effects. Existing physics based Atmospheric Correction (AC) algorithms for multi/hyper-spectral remote sensing data over land involves simultaneous use of visible and Short-Wave Infrared (SWIR) channels to derive aerosol information. Hence, such algorithms cannot be used for AC of data acquired by VNIR sensors to derive "surface reflectance".

Towards this, Space Applications Centre, Ahmedabad has developed a new algorithm for AC of high resolution VNIR remote sensing data in which aerosol information is retrieved from sensor measurements in VNIR channels and by selecting appropriate aerosol optical properties from a set of defined aerosol models. The algorithm uses lookup tables generated with vector radiative transfer calculations. Derived aerosol information and pre-computed lookup tables are employed to derive surface reflectance. Good quality surface reflectances have been obtained when this algorithm was applied on Cartosat-2 Series Satellite data. It is found that this algorithm significantly removes the haze from the images, making surface features distinctly visible, and hence more useable for qualitative as well as quantitative analysis and further applications.

Following figures illustrate the drastically improved quality of the images after applying the AC algorithms, where contribution of light due to molecular scattering and scattering from a thick layer of aerosol to the sensor measurement at top of the atmosphere is removed.

Parts of Ahmedabad as viewed from Cartosat-2 Series Satellite on November 03, 2016

National Workshop on Popularisation of Remote Sensing Based Maps and GIS

A National Workshop on Popularisation of Remote Sensing Based Maps and Geo-spatial Information was organised jointly by ISRS and ISRO on the eve of National Remote Sensing Day on August 11, 2017 at Indian Institute of Remote Sensing (IIRS), Dehradun. National Remote Sensing Day (August 12) is celebrated every year on the occasion of birth anniversary of Dr. Vikram Sarabhai, the Father of the Indian Space Programme. The Indian Society of Remote Sensing (ISRS), having around 5000 life members, has been in the forefront in popularising Remote Sensing in the country as well as in the Asia-Pacific region. This workshop is a follow-up action of National Meet held in September 2015, with an objective to popularise space-based products and services in the central and state user departments to benefit social welfare schemes.

The programme was broadcast through different modes like live streaming at ISRS/ISRO/IIRS websites, A-View/Youtube channel and in offline modes. The Development and Educational Communication Unit (DECU) of ISRO provided the support in video coverage and packaging of the programme for video streaming.

Dr. A. Senthil Kumar, Director, IIRS welcomed all the participants. While addressing the participants he said that Remote Sensing and Geographic Information System provides critical inputs to various welfare programmes / schemes of Govt. of India for effective planning and decision-making.

Dr. Shailesh Nayak, President, ISRS in the opening remarks highlighted the role of ISRS in popularising Remote Sensing in the country as well as in the Asia-Pacific region. He said that ISRS believes that Remote Sensing and GIS should be the mainstay of our planning of economic, environmental as well as social programmes. He urged the participants to contribute towards enhanced use of Remote Sensing based information in the development of the country.

Dr. A. S. Kiran Kumar, Secretary, DOS and Chairman, ISRO in his inaugural address, greeted the participants on the occasion of National Remote Sensing Day. He told that the remote sensing has come a long way since the beginning of satellite remote sensing programme in 1975. He mentioned that today, Indian satellites have capability to provide even sub-meter spatial resolution and temporal coverage at 15 minutes interval. These data are being used for informed decision making in various applications such as prospective fishing zone identification, bore well location and identification, forest fire detection, and disasters management etc. He said ISRO is accomplishing the vision of Dr. Vikram Sarabhai who emphasised the use of remote sensing applications for addressing the problems of common man in the country.

Dr. Y. V. N. Krishna Murthy, Director, NRSC gave an overview of activities of NRSC and diverse areas of space technology, which is helping central ministries and state departments. Dr. Tapan Misra, Director, Space Applications Centre (SAC) in his address, talked about ISRO's Earth Observation sensors, their characteristics and applications. Dr. P.G. Diwakar, Scientific Secretary, ISRO talked about India's Bhuvan Geo-portal, its features, products, services and

future activities, Dr. S.K. Srivastav, Group Director, IIRS provided an overview of capacity building and outreach programme of IIRS. Dr. Uday Raj, Chief General Manager, RRSC/NRSC talked about the space inputs for decentralised planning, and SIS-DP initiatives of ISRO. Shri P.L.N. Raju, Director, NE-SAC talked about the use of geo-spatial technology in the North-Eastern region.

ISRO's Bhuvan team gave a demo on ISRO's Bhuvan Geo-Portal and its use for various projects / schemes of Government of India. SAC team highlighted the features and services provided through VEDAS Portal. IIRS team gave a demo on Indian Bio-resource Information Network (IBIN) Portal and its online services.

A live panel discussion was held at the state-of-the-art studio of IIRS. The panel was joined by the senior dignitaries from Forest Survey of India (FSI), Dehradun, Wildlife Institute of India (WII), Dehradun, Wadia Institute of Himalyan Geology (WIHG), Earth and Climate Sciences Area (ECSA), National Remote Sensing Centre (NRSC), Hyderabad and Director, IIRS and CSSTEAP, Dehradun. The panel discussion was moderated by Director, IIRS. The panelist put forward their views on the utilisation of space technology in their respective domains and also highlighted the areas in which application of geo-spatial technologies needs to be demonstrated and transferred to the user departments. Dr. Sameer Saran, Secretary, ISRS and Head, Geo-informatics Department, IIRS offered a formal vote of thanks for all those who contributed to organisation of the workshop and also the participants.

The workshop proved to be one of the largest mass awareness and sensitisation programmes on remote sensing applications in the country. Nearly one lakh people witnessed the proceedings of the workshop from different parts of the country. The participants belong to ISRS local chapters, IIRS Distance Learning Network of academic and research institutions, IITs, ICAR, MoEF&CC and DST institutes, ISRO Centres (ISRO HQ, ISAC, NRSC including RRSCs, SAC, IIRS, NE-SAC and State Remote Sensing Centres), NGOs and many schools.

ISRO Organises Outreach Programme in Hindi at Ranchi

Creating awareness among the general public, especially students, about the benefits that have accrued from India's applications driven space programme to the society and the progress made by the country in space science and technology has been given utmost importance at ISRO. Media campaigns on important events, campaign through social media, organisation of exhibitions, educational activities like lectures, interactive sessions with students, quiz programmes, water rocket making and launching events, publications, video documentaries, etc., have helped in not only keeping the public abreast of the latest developments in our space programme but also to evoke interest in them on the nuances of space science and technology.

In this regard, an outreach programme was organised by ISRO at Jawahar Vidya Mandir at Ranchi, the capital of the state of Jharkand during August 3-4, 2017. The various events of this programme consisted of an exhibitions, interactive programme with students and the teaching staff, parents, visiting general public; a water rocket launch event; and a quiz programme on space and astronomy. The event was inaugurated by the Honorable Chief Minister of Jharkhand State, Mr Raghuvar Das, on August 03, 2017. In his inaugural speech, the Chief Minister said that science promotes both nationalism and self-reliance. He appealed to the people to encourage the younger generation to take interest in the scientific activities and stressed the need for taking such programmes to large parts of the country.

Hon'ble Chief Minister in the Inaugural Function

The highlight of the ISRO Exhibition was that all the information was presented in Hindi since the Department of Space has a mandate to organise such programmes in the language of the masses to enable them to understand better. Accordingly, this exhibition, was organised, especially to implement the recommendations of the Joint Hindi Salahkar Samiti for DOS & DAE to effectively reach out to the masses.

About 70 colourful exhibition panels highlighted the achievements of India in space to the student community as well as the general public. Besides, the exhibition also featured panels providing fundamentals of the various facets of space flight and the unique contribution of space technology to the country's rapid and all round development. Eight scale models of various satellites and spacecraft including the Mars Orbiter Mission spacecraft as well as Chandrayaan-1 and its Moon Impact Probe were showcased in the exhibition. There were also three scale models of India's rockets – the workhorse launch vehicle PSLV that launched a record 104 satellites in February 2017, GSLV-Mk II equipped with the indigenous cryogenic upper stage and which has scored four consecutive successes, and more importantly, GSLV-Mk III that launched the heaviest Indian satellite launched so far from India (3136 kg GSAT-19 in June 2017), exhibited.

Video documentaries on various space endeavours of India like Mars Orbiter Mission and AstroSat, were repeatedly screened during the exhibition. A group of students were trained to provide explanation about the exhibits for empowering them to explain the

nature, importance and significance of the country's space capabilities. During the interaction, students and general public evinced keen interest in the Indian Space Programme and asked insightful questions.

Another important feature of this ISRO outreach programme was the launch of water rockets in the school grounds. During the launches, students were provided with information about the basic principles behind rocket propulsion in general and water rockets in particular. Many students were provided with opportunity to launch water rockets themselves. Both students and teachers as well as the general public enthusiastically participated in the water rocket launching events.

A quiz on space and astronomy was also organised during the event. About 100 students from various schools in Ranchi participated in the preliminary round in which 18 students were short listed for the final round. The extent of involvement of students in the quiz programme revealed their interest in spaceflight as well as their fundamental scientific knowledge. The finalists were suitably rewarded by the department with cash prizes as well as a book on spaceflight.

The ISRO outreach programme at Ranchi yet again revealed the country's student community's interest in as well as the appreciation of the country's space programme and their eagerness to pursue a career in science and technology in general and join the country's space endeavour in particular. The facilities provided for the event by the Jawahar Vidya Mandir, Shyamali, the host institution at Ranchi, were instrumental in the success of this outreach event in Hindi.

More than 10,000 students from 60 schools in Ranchi attended the outreach event, which was widely reported by the print and electronic media.

PSLV-C39 Flight Carrying IRNSS-1H Navigation Satellite Unsuccessful

The forty-first flight of India's Polar Satellite Launch Vehicle (PSLV-C39), carrying IRNSS-1H Navigation Satellite conducted on August 31, 2017 from SDSC, SHAR, Sriharikota, was unsuccessful. The IRNSS-1H satellite was identified as the eighth satellite to join the NavIC navigation satellite constellation. PSLV-C39 had a normal lift-off and all the launch events occurred successfully except the heat shield separation, due to which the satellite could not be injected into the orbit. Detailed failure analysis was completed by the Failure Analysis Committee to identify the anomaly that led to the non-separation of the heat shield. The recommendations of the Failure Analysis Committee were implemented.

ISRO Develops Optical Imaging Detector Array for Hyperspectral Imaging Applications

ISRO is endeavouring to enter the domain of operational hyperspectral imaging from earth orbit. To find a suitable detector array for the proposed Hyperspectral Imaging Satellite's (HySIS) payload in terms of performance and delivery schedule for meeting the project requirements, a detailed survey was conducted.

Vis-NIR Hyperspectral payload of HySIS satellite is a hyperspectral imaging sensor operating in the visible and near infrared regions of the electronmagnetic spectrum. This earth observing imaging spectrometer will operate in the 0.4 to 0.95 μm spectral range, will have 55 spectral bands with 10 nanometre spectral sampling and 30 metre spatial sampling. Push-broom scanning mode is the operating mode of this sensor from a 630 km orbit.

Following the survey to find detector arrays, Vis-NIR Hyperspectral Imaging payload was originally conceptualised around a commercial off-the-shelf detector array developed by a foreign supplier. For the shortlisted detector array from that supplier, the pixel size, charge handling capacity and Signal-to-Noise ratio were not complying with the requirements.

So, these requirements were subsequently proposed to be met at the system level by employing the technique of 'spatial and spectral signal binning'. But, following the recommendations during a prominent review, the payload team worked out a plan for indigenous development of a 'Frame Transfer Charge Coupled Device' (CCD 1000 X 66, 11 μm x 26 μm). In this regard, the Space Applications Centre (SAC) discussed the work breakdown and sharing structure with Semi Conductor Limited (SCL), Chandigarh, an autonomous body under the Department of Space, and the same was laid out between SAC and SCL team members.

As per the discussion, chip architecture, device design, chip layout, and package design were carried out at SAC to meet project requirements with respect to spatial and temporal resolution, Dynamic Range, Modulation Transfer Function, Smear and spectral responsivity. 1000 X 66 pixels were designed to be readout, from both top and bottom directions, using four analog video ports to meet the frame rate requirement. Metal strapping was used for swiftly transferring integrated charges from image to storage

(FT CCD 1000 x 66, Chip Architecture)

region, in order to reduce image smear. Designs (both at chip and package levels) went through detailed review, before clearing for mask making and package fabrication, by a team consisting of members from SCL and SAC.

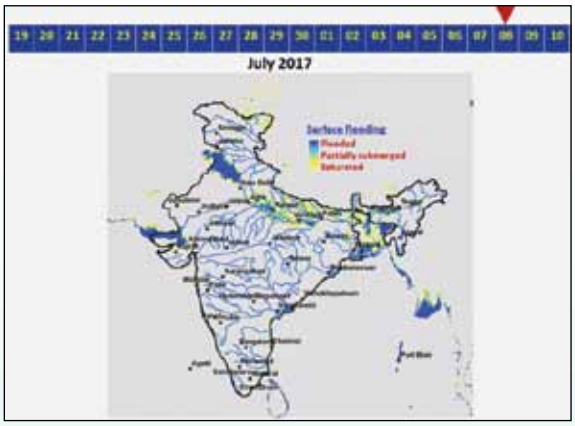
Wafer processing was completed at SCL with top priority. During wafer processing at SCL, the SAC team developed a test bench (Hardware, Firmware, and software for providing electro-optical stimuli) for electro-optical evaluation of the chip. Wafer level testing, assembly and packaging were carried out at SCL. Few dies were packaged (Chip-on-board) at SCL for functionality verification.

The Chip on Board (COB) packages have successfully gone through functionality verification checks at SAC.

Flood Monitoring using SCATSAT-1 Satellite

Monsoon was active over different regions of India especially in Gujarat, Eastern Uttar Pradesh, Western Bihar, Assam and lately in West Bengal during mid July 2017. Heavy rains have created severe floods in these regions with extreme flood in parts of Gujarat and neighboring areas. Districts namely Banaskantha, Ahmedabad, Gandhinagar, Mehsana, Patan, Sabarkantha, etc., recorded more than 300% rainfall above average level during July 20, 2017 to July 26, 2017.

Satellite plays an important role in the detection and monitoring of flood situations over large regions. Optical remote sensing from geostationary platform (INSAT-3D/3DR) provides rapid and valuable information



Flood as Observed from SCATSAT-1

on cloud patterns and meteorological parameters (rainfall); however, unable to image the surface water conditions in presence of cloud. Microwave remote sensing techniques have unique advantage in which electromagnetic radiation penetrate the clouds and senses the surface hydrological characteristics. The data from SCATSAT-1 (launched by PSLV-C35 on September 26, 2016) was used for the detection of the flood situations over India.

SCATSAT-1 is a continuity mission for Oceansat-2 Scatterometer for Ocean weather forecasting, cyclone detection and tracking. The satellite carries Ku-band Scatterometer and scans in a conical fashion in HH and VV polarizations and allows developing high-resolution datasets due to high overlapping areas. SCATSAT-1 observations in Ku-band for backscattering and brightness temperatures have been analyzed for flood detection and monitoring over India with special emphasis in Gujarat and southern parts of Rajasthan.

Merging of backscattering and brightness temperature data helped to delineate the regions, which were flooded, partially submerged or existed in different soil wetness conditions (saturated or dry). Inundated areas have been obtained during second week of July over Ganga (Kanpur to Patna and Kosi river) and Brahmaputra flood plains. Extreme flooding conditions were observed in Ahmedabad, Mehsana, Kheda, Banskantha and Bhavnagar as compared to relatively dry conditions in Bharuch during fourth week of July along with moderate inundation in parts of West Bengal.

Sentinel-1A, a C-band SAR imaging satellite high resolution data on July 24, 2017 helped to compare inundated regions over parts of Gujarat. Observations on flooding conditions were well correlated in SCATSAT-1 and Sentinel-1A data.

Analysis showed the usefulness of SCATSAT-1 mission in detecting and monitoring extreme events such as flood with high temporal resolution (daily). Further details can be obtained from VYOM and VEDAS web portal of Space Applications Centre.

Indigenous Ship Bound Terminal Tracks PSLV-C38 Geo-spatial Information Trajectory Successfully

ISRO Telemetry, Tracking and Command Network (ISTRAC), Bengaluru is entrusted with the major responsibility to provide tracking support for all the satellite and launch vehicle missions of ISRO. ISTRAC has also been mandated to provide space operations support for Deep Space Missions of ISRO. For supporting Deep Space Missions, a large number of ground stations are required to provide Telemetry Tracking and Command (TTC) support during the launch and initial phase. Based on the launch vehicle trajectory and visibility requirement, many a time, the TTC stations are to be located in mid sea, wherein, conventional Ground Station Antenna will not be suitable. In order to cater to these specific requirements, ISTRAC has designed and developed a 4.6 meter Ship Borne Transportable (SBT) Antenna Terminal that meets the launch vehicle TTC requirements.

The SBT Antenna system consists of 3-axis Antenna Mount, a Motion Simulator, Reflector & Feed, Servo Control Systems and RF Electronics. Mechanical Systems Area (MSA) of ISTRAC made a detailed study of the technical requirements, availability of similar systems internationally and derived state-of-the-art specifications. The major design challenges in this system are: Development of a 3-axis antenna mount to compensate for the pitch, roll and yaw disturbances of the ship during tracking of the launch vehicle; Design and develop a motion simulator to simulate the base disturbances experienced by the ship during sea state condition; Flexibility for change over from S-Band TTC station to X-Band TTC station with minimum hardware changes; Packaging the entire system within the standard ISO container is a very important requirement towards shipping to other countries; and Redundancy in drive systems.

The final system performance and validation was carried out by a sea trial, wherein, the Antenna system was integrated on SAGAR MANJUSHA Ship hired from National Institute of Ocean Technology (NIOT). The ship was stationed at a specified observation point in Bay of Bengal and has successfully tracked PSLV-C38 launch vehicle from predicted Acquisition Of Signal (AOS) time (T+60sec) to Loss Of Signal (LOS) time (T+596sec) in auto track mode. The quality of the data acquired was as per the prediction.

The Antenna system was realised with the participation of Indian Industries and has been tested and validated on a motion simulator. ISRO has built this 4.6 meter Ship Borne Antenna System indigenously, thus fulfilling all the specifications and has established in-house capability for meeting future requirements.

SBT Antenna on sea trial during PSLV-C38 launch

It also improved the operational reliability due to in-house know-how of the systems engineering, besides reducing the cost considerably.

Outreach Facility at NRSC Inaugurated

National Remote Sensing Centre (NRSC) established a new Outreach Facility at Jeedimetla Campus in Hyderabad to cater to the ever growing requirements of capacity building in Space-based applications. The facility was inaugurated by Shri A.S. Kiran Kumar, Chairman, ISRO / Secretary, Department of Space on June 26, 2017. This facility caters to several activities like Training and Capacity Building, Information Kiosks, Content Generation, Outsourcing and Mass Communication, which could be conducted in parallel.

The facility has a large number of thin client systems connected to database servers and Bhuvan Geo-portal for massive content preparation. In addition, the user has access to satellite data and various applications software for meeting specific requirements of NRSC. Student community and industry can fully take advantage of this facility for various developmental activities.

Students and faculty members from various academic institutions including Telangana State Social Welfare Residential Educational Institutions actively participated in the inauguration. Technical presentations were also made by enthusiastic students on High value Menthol Mint crops, Geo-tagging applications of MGNREGA and other Remote Sensing & GIS applications. Presentations were also done on mobile app "Bhuvan - Aahar", a new application for food donor and the food receiver with a focus on facilitating the food dissemination to needy. Specific application on Bhuvan Kiosk was also demonstrated during the occasion.

Chairman, ISRO interacted with all the participants on various aspects of the project works undertaken by them. He was also of the opinion that the benefits of space technology developments should reach the common man and youth should join this endeavor in large number. He urged the Academia and Industries to utilize the facilities, made available at Jeedimetla, to the fullest extent and provide best possible solutions to the scientific challenges and help in national development.

Contact: NRSC Jeedimetla Outreach facility, Jeedimetla, Hyderabad by Email: gmoutreach@nrsc.gov.in

Jeedimetla Outreach Facility

A Tribute to Prof. U R Rao

(March 10, 1932 – July 24, 2017)

Prof. Udupi Ramachandra Rao, popularly known as Prof. U R Rao, is an internationally renowned space scientist who made original contributions to the development of space technology in India and its extensive application to communications and remote sensing of natural resources.

He was the Chairman of the Governing Council of the Physical Research Laboratory at Ahmedabad and the Chancellor of the Indian Institute of Space Science and Technology at Thiruvananthapuram. After working as a Faculty Member at MIT and Assistant Professor at University of Texas at Dallas where he carried out investigations as a prime experimenter on a number of Pioneer and Explorer spacecrafts, Prof. Rao returned to India in 1966 as Professor at the Physical Research Laboratory, Ahmedabad.

Convinced of the imperative need to use space technology for rapid development, Prof. Rao undertook the responsibility for the establishment of satellite technology in India in 1972. Under his guidance, beginning with the first Indian satellite 'Aryabhata' in 1975, over 18 satellites were designed and launched for providing communication, remote sensing and meteorological services.

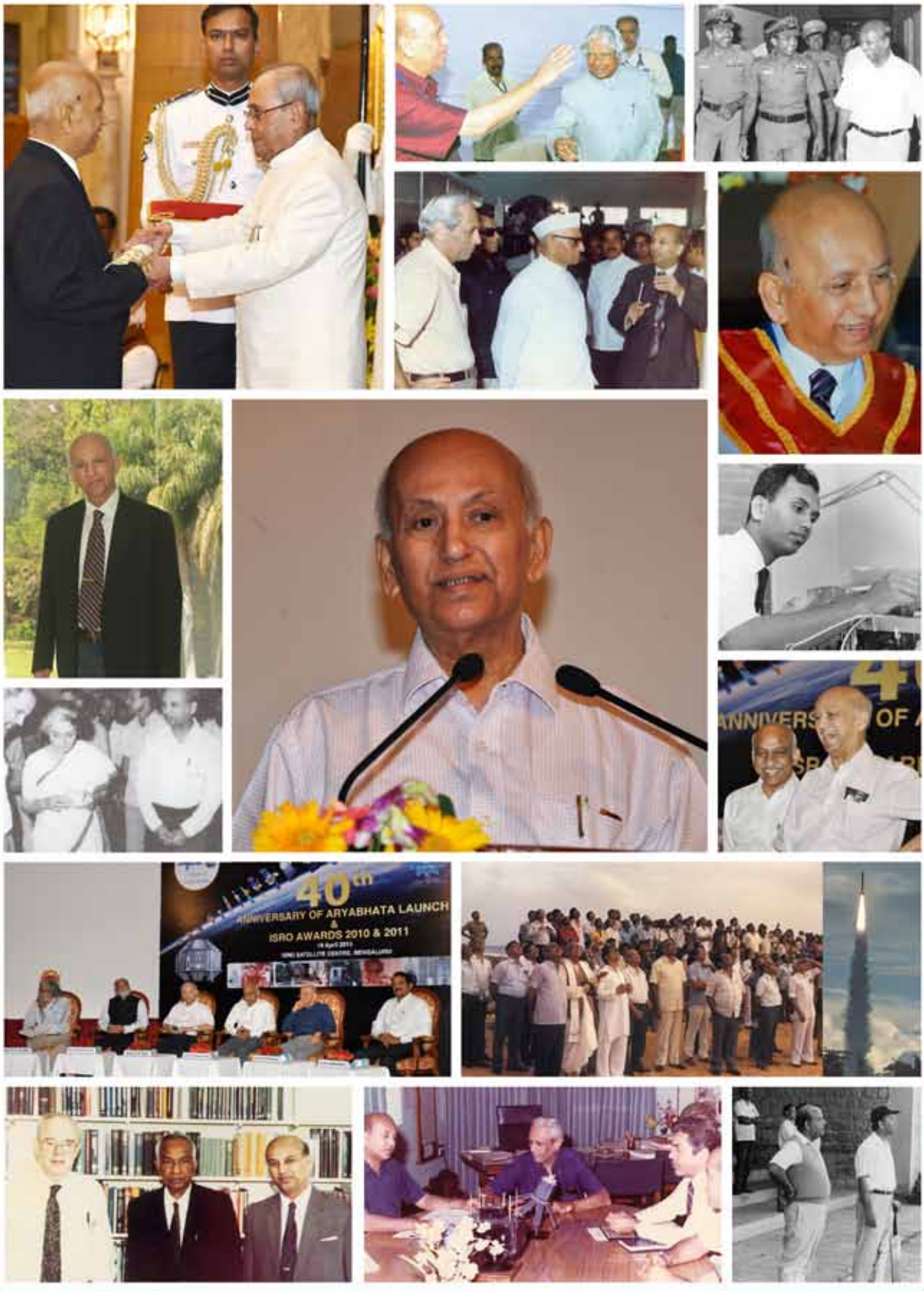
After taking charge as Chairman, Space Commission and Secretary, Department of Space in 1984, Prof. Rao accelerated the development of rocket technology, resulting in the successful launch of ASLV rocket and the operational PSLV launch vehicle, which can launch 2.0 ton class of satellites into polar orbit. Prof. Rao initiated the development of the geostationary launch vehicle GSLV and the development of cryogenic technology in 1991.

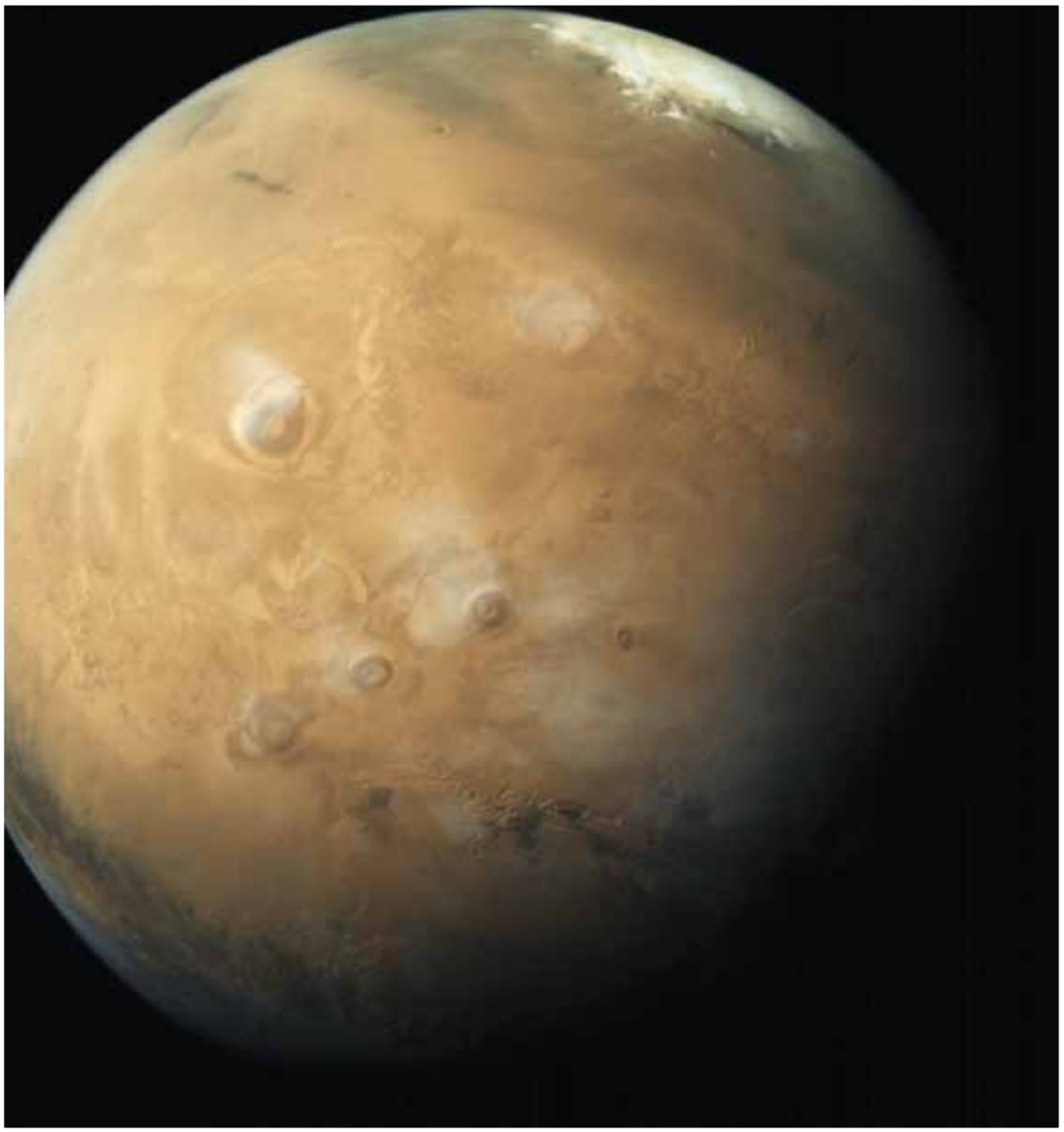
Prof. Rao had published over 350 scientific and technical papers covering cosmic rays, interplanetary physics, high energy astronomy, space applications and satellite and rocket technology and authored many books. He was also the recipient of D.Sc. (Hon. Causa) Degree from over 25 Universities including University of Bologna, the oldest University in Europe.

Prof. U R Rao was awarded with **Padma Bhushan** – the third highest civilian award – by the Indian Government in 1976 for his contribution to Indian Space technology. In 2017, he was awarded the **Padma Vibhushan** - the second highest civilian award. Prof. Rao had the unique distinction of being the First one from outside the select group of countries like USA, USSR and Europe to be elected as Chairman of the United Nations Committees on Peaceful Uses of Outer Space (UN-COPUOS), Vienna in 1997. He was also the first Indian Space Scientist to be inducted into the **"Satellite Hall of Fame"** at Washington in 2013 and **"IAF Hall of Fame"** at Guadalajara in Mexico in 2016.

Prof. Rao served ISRO as Chairman from **1984 to 1994.**

The ISRO/DOS community grieves the passing away of Prof. U R Rao on July 24, 2017 and remembers with gratitude his precious contributions to the Indian space programme.


40th
ANNIVERSARY OF ARYABHATA LAUNCH
&
ISRO AWARDS 2010 & 2011



This image covers Mars Disc in a Perspective/Ortho view with 3.5 km per pixel resolution and obtained after the blackout period experienced by MOM. Olympus mons, and three volcano systems Arsia mons, Pavonis mons, Ascraeus mons opposite to Olympus mons system are seen prominently in this shot. This picture was taken by MCC on Oct 08, 2017 from an altitude of 70,157 km.

Antariksh Bhavan, New BEL Road, Bengaluru - 560 094, India.
www.isro.gov.in