

## Department of Space

\*\*\*\*\*

Following are the significant achievements and details of the Innovative Programmes launched by the Department of Space:

### **Launch Vehicle Programme**

#### **Polar Satellite Launch Vehicle (PSLV)**

In the past three years (June 2014-March 2017), all the 13 launches of India's versatile workhorse launch vehicle PSLV have been successful. During this period, the vehicle has launched 16 Indian satellites (including four student satellites) as well as 146 foreign satellites into a variety of orbits, thereby repeatedly proving its reliability and versatility.

PSLV-C37, the thirty ninth launch of India's workhorse launch vehicle PSLV, achieved worldwide fame by launching 104 satellites in the planned polar Sun Synchronous Orbit of 505 km height. It was the 38<sup>th</sup> consecutively successful launch of PSLV also. Of the 104 satellites carried onboard PSLV-C37, three were Indian and the remaining 101 were co-passenger satellites for foreign customers. The primary satellite carried by PSLV-C37 was the India's 714 kg Cartosat-2 series satellite, whereas the other two were nano satellites of India named INS-1A and 1B weighing 8.4 and 9.7 kg respectively. Of the 101 customer nano satellites carried, 96 were from USA and one each from The Netherlands, Switzerland, UAE, Kazakhstan and Israel. The video from the onboard cameras of PSLV showing the progress of the successful launch including the separation of satellites in orbit has become very popular all over the world with the web versions of many national and international media houses hosting it with appreciation.

Earlier in 2016, PSLV had successfully launched India's RESOURCESAT-2A remote sensing satellite into a 817 km polar Sun Synchronous Orbit in its 38<sup>th</sup> flight (PSLV-C36). Before that, PSLV successfully launched eight satellites including India's SCATSAT-1 and two Indian University/Academic institute satellites in its 37<sup>th</sup> flight (PSLV-C35). The rest were customer satellites from abroad. And, in its 36<sup>th</sup> flight (PSLV-C34) conducted on on June 22, 2016, PSLV successfully launched 20 satellites in a single flight including India's CARTOSAT-2 series satellites and two Indian University/Academic institute satellites. Prior to this, the first three PSLV launches of 2016 were successful in putting three IRNSS series of satellites into orbit on January 20, March 10 and April 28 respectively.

During 2015, all the four PSLV launches conducted from Satish Dhawan Space Centre SHAR, Sriharikota were successful and two of the missions were dedicated ones for launching customer satellites from abroad. The successful launch of ASTROSAT, India's first multi wavelength space observatory onboard PSLV, was one of the highlights of 2015.

During May-December 2014, the two launches of PSLV were successful and one of them placed five customer satellites from abroad, including the 714 kg French SPOT-7 satellite into orbit while the other successfully launched India's IRNSS-1C satellite.

**Commercial Launches of PSLV:** In the past three years India's Polar Satellite Launch Vehicle has launched a total of 145 foreign satellites from 12 countries (Algeria, Canada, France, Germany, Indonesia, Israel, Kazakhstan, Singapore, Switzerland, UAE, UK, and USA) including the 101 satellites launched by the PSLV-C37 on February 15, 2017. Three of the PSLV launches during the past three years were exclusive commercial missions to launch customer satellites from abroad.

## **Geosynchronous Satellite Launch Vehicle (GSLV)**

### **GSLV Mark II**

In the past three years, GSLV MkII, equipped with the indigenous Cryogenic Upper Stage (CUS), has two consecutively successful flights during which it has launched two satellites into the planned Geosynchronous Transfer Orbits (GTO). On September 08, 2016, GSLV Mk II launched India's weather satellite INSAT-3DR into the planned GTO. Earlier, GSLV MkII had successfully launched India's GSAT-6 communication satellite into the planned GTO on August 29, 2015. These two flights, coupled with the previous flight of GSLV MkII successfully conducted on January 05, 2014, signify India's competence in the highly complex cryogenic rocket propulsion technology.

### **Development of Next Generation Geo-Synchronous Satellite Launch Vehicle Mk III:**

India's next generation launch vehicle GSLV MkIII, the heaviest launch vehicle developed by ISRO, had its successful maiden suborbital test flight on December 18, 2014. It carried the 3775 kg Crew Module Atmospheric Re-entry Experiment (CARE) to a height of 126 km following which CARE module re-entered the atmosphere and successfully recovered after it landed over Andaman Sea about 1600 km from Sriharikota. On February 17, 2017 the indigenously developed C25 Cryogenic Upper Stage (CUS) for GSLV MkIII was successfully ground tested for the flight duration of 640 seconds at ISRO Propulsion Complex (IPRC) in Mahendragiri, Tamil Nadu. This Stage test was a significant milestone as it was the last in series of engine and stage development hot tests before the first development flight of GSLV MkIII. The C25 stage is the most powerful upper stage developed by ISRO and uses Liquid Oxygen (LOX) and Liquid Hydrogen (LH2) propellant combination.

## **Advanced Launch Vehicle Technology Initiatives**

During the year 2016, research and development activities in reusable launch vehicle technology and air breathing propulsion got a boost with the successful maiden flights of two advanced launch vehicle technology initiatives of ISRO – the Reusable Launch Vehicle-Technology Demonstrator (RLV-TD) and SCRAMJET Engine Technology Demonstrator. On May 23, 2016, the first flight test of India's RLV-TD was successfully conducted from Satish Dhawan Space Centre SHAR, Sriharikota. On August 28, 2016, ISRO's SCRAMJET engine technology demonstrator was successfully flight tested from Satish Dhawan Space Centre SHAR, Sriharikota. Both these initiatives are intended to reduce the cost of access to space.

## **Satellite Programme**

In the past three years, 17 ISRO satellites have successfully reached orbit and most of them have been launched by the indigenous PSLV and GSLV. Besides, four Indian University/Academic institute satellites have also been launched indigenously.

### **Communication satellites**

From May 2014, four communication satellites – GSAT-16, GSAT-6, GSAT-15 and GSAT-18 – are providing various services after reaching their final geostationary orbit home. Of them, GSAT-6 was launched by GSLV-D6 in August 2015. Besides, communication transponders, GSAT-15 carries GPS Aided Geo Augmented Navigation payload as well.

GSAT-18, a 3.4 ton communication satellite (carrying a total of 48 transponders in C, Extended C and Ku- bands) was successfully launched on October 06, 2016. This latest addition to INSAT/GSAT system of communication satellites further augments the system capacity for providing various communication services to the country.

### **Earth observation satellites**

In the past three years, five earth observation satellites – two CARTOSAT-2 series satellites, INSAT-3DR, SCATSAT-1 and RESOURCESAT-2A – have been launched and all of them were launched indigenously by PSLV or GSLV MkII. Of these, INSAT-3DR is in geostationary orbit whereas the other four are in polar Sun Synchronous Orbits (SSO) with their altitude ranging from 500 to 820 km.

A CARTOSAT-2 series satellite, equipped with panchromatic and multispectral cameras, successfully became operational after being launched into a 505 km polar SSO by PSLV-C34 on June 22, 2016. The imagery from the satellite will be useful for cartographic applications, rural and urban applications, coastal land use and regulation, utility management like road network monitoring, water distribution, creation of land use maps, precision study, and change detection to bring out geographical and manmade features and various other Land Information System (LIS) and Geographical Information System (GIS applications).

INSAT-3DR, an exclusive weather satellite equipped with an imager, a sounder, a weather data relay transponder and satellite aided Search and Rescue Transponder, and weighing 2211 kg at lift-off, reached the planned Geosynchronous Transfer Orbit (GTO) onboard GSLV MkII on September 08, 2016. Later, with the help of its own propulsion system, the satellite reached its 36,000 km geostationary orbital home and began providing inputs for accurate weather forecasting.

The 371 kg SCATSAT-1 satellite, carrying a Ku-band scatterometer, successfully reached the intended polar Sun Synchronous Orbit of 720 km height onboard PSLV-C35 on September 26, 2016. It 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.

Resourcesat-2A, equipped with a three tier imaging system consisting of LISS-4, LISS-3 and AWiFS cameras and weighing 1235 kg at lift-off, successfully became operational after reaching a polar Sun Synchronous Orbit of 822 km height onboard PSLV-C36 on December 07, 2016.

On February 15, 2017, another CARTOSAT-2 series satellite, with capabilities similar to that of CARTOSAT-2 satellite launched on June 22, 2016, successfully reached its planned polar SSO of 505 km height by PSLV-C34.

### **Navigation satellites**

The successful launch of the 1425 kg IRNSS-1G, the seventh satellite in the Indian Regional Navigation Satellite System onboard the thirty fifth flight of India's workhorse Polar Satellite Launch Vehicle (PSLV-C33) in April 2016 and its subsequent operationalisation signified the completion of IRNSS constellation. The Prime Minister of India, Shri Narendra Modi, heartily thanked and congratulated all the ISRO scientists and team ISRO for completing IRNSS constellation and dedicated IRNSS to the nation as 'NavIC' (Navigation Indian Constellation).

IRNSS is an independent regional navigation satellite system designed to provide position information in the Indian region and 1500 km around the Indian mainland. IRNSS provides two types of services, namely, Standard Positioning Services (SPS) - provided to all users and Restricted Services - (RS), provided to authorised users.

A number of ground facilities responsible for satellite ranging and monitoring, generation and transmission of navigation parameters, etc., have been established in eighteen locations across the country. Five IRNSS-1C, 1D, 1E, 1F and 1G, the third, fourth, fifth, sixth and seventh satellites of the IRNSS constellation have been successfully launched in the past three years.

## **MARS Orbiter Mission**

India's Mars Orbiter Spacecraft was successfully placed into an elliptical orbit around planet Mars on September 24, 2014.

MOM spacecraft was built to function for six months in Mars Orbit, but the spacecraft has performed beyond expectations. The health parameters of Mars Orbiter spacecraft are normal and all the five payloads are sending useful data on Mars surface and its atmosphere. More than 530 good quality images of Mars are captured by the Mars Colour Camera and have been received and processed at ISRO Space Science data center. Imaging of the two Moons of Mars, 'Phobos and Deimos', has revealed new details about these objects. 'Mars Science Atlas', with varieties of pictures of Mars has also been brought out to kindle young minds on space and planetary explorations. The Archived data is now made public for free download and scientific research through ISRO's website. More than 1.75 Lakh hits and about 40 GB data was downloaded in just 2 weeks. There are 17 publications, more than 1175 registered users and 10,500 download amounting to 290 GB of data. ISRO has also launched MOM Announcement of Opportunity (AO) programs for researchers in the country to use the MOM data for R&D. The success of Mars Orbiter Mission shown India's technical capability in exploring planetary bodies and has motivated India's student and research community in a big way.

The Mars Orbiter Spacecraft successfully came out of the solar conjunction (a phase of communication blackout) in July 2015 using the On-board autonomy built in the spacecraft. On January 17, 2017, an orbital manoeuvre was successfully performed on Mars Orbiter Mission (MOM) spacecraft to avoid the impending long eclipse duration for the spacecraft.

## **India's first multi-wavelength Observatory in Space**

ASTROSAT, India's first multi wavelength observatory has completed one year in orbit as of September 2016. This dedicated astronomy satellite has helped to study distant celestial objects by collecting and recording the visible light as well as ultraviolet and X-rays emitted from heavenly bodies. An Announcement of Opportunity (AO) was made in June 2016 for Indian researchers to explore the universe using data from ASTROSAT. As a part of one year completion of ASTROSAT in orbit, a one-day workshop was organised at Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune on Sept 29, 2016, to highlight the technical and scientific achievements of this satellite. The first scientific set of results and the future scope of the satellite were presented during the meeting. During this period of one year, the spacecraft has orbited the earth more than 5400 times and

has executed 343 individual pointing to 141 different cosmic sources. The observed data are being routinely downloaded at the Indian Space Science Data Centre (ISSDC) at Byalalu near Bangalore.

## **Applications**

The successful operationalisation of the communications, earth observation and navigation satellites in their intended orbits during the past three years has ensured the continuity of various services offered earlier besides enhancing the quality of some of those services. In this regard, while INSAT/GSAT series of satellites have enhanced the number of communication transponders and weather monitoring payloads, the CARTOSAT, Resourcesat and SCATSAT series of satellites have significantly enhanced our capability to survey precious natural resources, undertake many cartography related applications and to understand the interaction between the oceans and the atmosphere. And the NavIC (IRNSS) series of Navigation satellites have enabled us to develop the capability to provide accurate position, navigation and time information in and around India.

## **Disaster Management Support**

During the past three years, the Indian Remote Sensing, Meteorological and Communication satellites have greatly helped in the management of many disaster events witnessed by the country including wide spread floods in 11 states and a major forest fire in Uttarakhand State in 2016. The depressions formed in the Bay of Bengal including the cyclonic storms Roanu in May 2016 and Kyant in October 2016 was monitored and the cyclone track and intensity were predicted. All the information were regularly updated on the MOSDAC website as part of information dissemination. In the 2016 fire season, many forest fire locations were generated using MODIS satellite data. Near real time observations were provided to the Ministry of Home Affairs and the Uttarakhand State Government for addressing the forest fire episodes that occurred in Uttarakhand in 2016. Value added active fire locations are disseminated through Bhuvan. At the international level, in 2016, ISRO supported 23 disaster events in 10 countries by providing 42 data sets from IRS satellites.

## **Monitoring and evaluation of developmental activities in the watersheds**

Department of Land Resources programme on Integrated Watershed Management Programme (IWMP) is for restoring the ecological balance by harnessing, conserving and developing degraded natural resources such as soil, vegetative cover and water. ISRO is providing online satellite data, tools and mobile app through Bhuvan geoportal for monitoring of watershed developmental activities for about 52,000 micro-watersheds in 10 States and 50 identified districts across the country.

## **Space Based Information Support for Decentralized Planning**

Bhuvan Panchayat Portal provides functionalities required to carry out the decentralized planning process at grass-root level. Citizens in general and three tiers of Panchayati Raj Institutions (PRIs) (Gram Panchayat, Block Panchayat and District Panchayat) in particular are the users of the Portal. It helps PRIs in tracking the progress of work undertaken by citizens under various schemes.

Automated warnings at unmanned level crossings: Pilot studies for automatic warnings at unmanned level crossings have been carried out using GAGAN, Rail-Navigator tools; MSS based tracking system and Bhuvan. It comprises of a geospatial database on the accurate locations (geographical coordinates) of unmanned level crossings and GAGAN enabled devices mounted on the train engine.

## **Bhuvan Geoportal**

Bhuvan is providing seamless high resolution remote sensing data (1m to 2.5m) for visualization, terrain data and thematic layer overlays of Indian region along with host of services in the areas of disaster, weather, land and ocean for general public. The portal has witnessed about one lakh unique visitors, 800 GB data transfer and more than 13, 000 downloads per month.

On 12th August 2015, the Union Minister of State (Independent Charge) Development of North-Eastern Region (DoNER), MoS PMO, Personnel, Public Grievances & Pensions, Atomic Energy and Space, Dr. Jitendra Singh, released New services of Bhuvan. The new application services include – 1 m images of over 300 Cities of the country and host of visualization applications for common man.

## **Data Connectivity to Rural India:**

DoS/ISRO has fast-tracked the realization and launch of GSAT-11 communication satellite. GSAT-11 is an advanced communication satellite with Ku and Ka Band communication payload capable of providing upto 10 Gbps throughput. With such capacity, this satellite is expected to provide high bandwidth data connectivity for rural India as envisaged under Digital India. Satellite structure is already realized and payload fabrication is in progress. Initiatives have been taken to accelerate the development and realization of other critical subsystems of the satellite. The satellite is targeted for launch in the year 2017.

## **National Meet on promoting Space Technology based tools and Applications on Governance & Development:**

The one day National Meet on promoting Space Technology based tools and Applications on Governance & Development was organized on September 07, 2015 at Vigyan Bhavan, New Delhi to deliberate on the action plans of various Ministries/Departments. The National Meet received an overwhelming response with

participation of more than 1200 delegates across 60 Central Ministries/Departments, 28 States and 5 Union Territories. Secretaries, Additional Secretaries, Joint Secretaries to Government of India, Chief Secretaries, Principal Secretaries of the States and senior functionaries of Central and State Governments, officials from Prime Minister Office & Cabinet Secretariat, young administrators (the fresh batch of 2013 IAS officers), experts from academia and institutions have actively participated in this Meet.

A Special Session was conducted in the presence of the Prime Minister Shri Narendra Modi. In his remarks, the Prime Minister emphasized the need for new initiatives in all the areas of governance, using the space technology and applications. He asserted that technology is the most powerful medium that the Government has to utilize to ensure good governance, transparency and accountability.

Follow-up Actions on National Meet for Application of Space Technology & Tools: Out of the 160 projects emerged as an outcome of national meet, work has been initiated in 144 projects. In about 90 projects, significant progress has been made in terms of development of methodology, web & mobile applications, execution of pilot studies, capacity building. About 75 customized web applications and 60 mobile applications have been deployed. As on date, 65 MoUs have been signed, which include 44 MoUs with Central Ministries/Departments and 21 MoUs with the State Governments. Based on the request of the Ministries/ Departments for capacity building, more than 9500 officials have been trained. Additionally, Outreach programmes have also been conducted in Colleges & Schools. State Meets on 'Promoting space technology based tools' have been completed for 10 States - Haryana, Bihar, Uttarakhand, Mizoram, Punjab, Rajasthan, Meghalaya, Jharkhand, Nagaland and Himachal Pradesh

There are varieties of applications of space technology that are being pursued with various Central and State Government Ministries/ departments. Some of the important highlights are 1) Near real-time support for disaster management; 2) Bi-weekly water body mapping and providing on public domain; 3) Annual mapping of Agricultural land use and Forest Loss alert system; 4) Hon'ble PM's PRAGATHI program uses regular inputs from Space and GIS; 5) Geotagging Applications for Rural Assets (MNREGA and IWMP programmes), Post Offices, Housing schemes, Soil Health Card, to name a few. There are many State-specific applications effectively integrated and used by State Government departments for various developmental purposes.

### **Initiatives on Satellite for SAARC Region**

In pursuance to Honorable Prime Minister's directive, ISRO has configured a communication satellite (**Satellite for South Asia**) with a host of space based services



for selected SAARC nations. ISRO/DoS, with active support from Ministry of External Affairs (MEA), hosted a Conference on “Satellite for the SAARC region and Space Technology Applications” on June 22, 2015 at New Delhi. The conference deliberated on configuration and ground Infrastructure requirements for the proposed ‘Satellite for the SAARC region’ as well as other space technology applications. Representatives from all SAARC member countries have participated. Based on the concurrence of the concerned SAARC-nations, the satellite is getting ready and will be launched on board GSLV-F09 during April 2017.

### **Awards & Recognition**

ISRO was conferred Gandhi Peace Prize for the Year 2014 for its contribution to Country’s development through Space Technology, which has led to Social Economic and Political Transformation through non violence.

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

MOM was declared as ‘one of the best inventions of 2014’ by TIME magazine.

MOM is also credited with - the spacecraft which has taken the maximum number of full disc images of Mars. November 2016 issue of National Geographic magazine carried one of the full disc images of Mars taken by the Mars Colour Camera of MOM on its cover page.

\*\*\*\*