

Indian Space Programme - Achievements

(May 2014 to April 2018)

Indian Space Research Organisation (ISRO) has completed 166 missions out of which 53 missions (23 Launch vehicle missions, 23 satellite missions & 7 technology demonstration missions) has been accomplished during the period May 2014 to April 2018.

Launch Vehicles

- a) **Polar Satellite Launch Vehicle (PSLV):** During the period, PSLV has completed 17 flights and has successfully orbited 224 satellites of total mass 19.2 tonnes in orbit. PSLV has demonstrated end to end launch services by launching 202 satellites for international customers from 24 countries including 3 dedicated commercial launches. PSLV upper stage (PS4) restart capability has also been demonstrated which enables PSLV to inject multiple satellites in different orbits in same mission thereby making PSLV more versatile launcher. **PSLV also created history by deploying 104 satellite in a single launch.** This remarkable exploit was a new moment of pride for scientific, space community and the country.
- b) **Geosynchronous Satellite Launch Vehicle (GSLV Mk-II):** ISRO has demonstrated the reliability of indigenous cryogenic technology with the four consecutive successful flights of Geosynchronous Satellite Launch Vehicle (GSLV) with indigenous Cryogenic engine & stage.
- c) **GSLV-Mark III:** The first experimental flight of GSLV MkIII (LVM3-X) was successfully launched on December 18, 2014. The valuable data generated from the experimental mission was utilized to improve the robustness of the vehicle. The first developmental flight was successfully launched, in which a 3136 kg communication satellite (GSAT-19) was injected into the Geosynchronous Transfer Orbit on June 05, 2017. **GSAT-19 is the heaviest satellite launched with Indian launch vehicle.**
- d) **Technology demonstration:** The **Crew module Atmospheric Re-entry Experiment (CARE)** was carried out in the experimental mission of GSLV MkIII on 18th Dec 2014, where the re-entry characteristics and the recovery of the Crew Module was

demonstrated. The first experimental mission of ISRO's **Scramjet engine** towards the realization of an Air Breathing Propulsion System which uses hydrogen as fuel and oxygen from the atmospheric air as oxidizer, was successfully conducted on August 28, 2016 with a hypersonic flight at Mach 6. With this test, **India became the fourth country to demonstrate the flight-testing of a Scramjet engine.** Towards developing essential technologies for a fully reusable launch vehicle to enable low cost access to space, ISRO successfully flight tested India's first winged body **Reusable Launch Vehicle - Technology Demonstrator (RLV-TD)** demonstrating Autonomous navigation, guidance and control & reentry mission management On 23rd May 2016. Three Indian nano satellites (INS-1A, INS-1B & INS-1C) and one microsat were launched which will pave way to host a variety of experimental payloads on a cost effective versatile satellite platforms.

1. Satellites- Communication, Navigation and Earth Observation

- a) **Communication Satellites:** Eight communication satellites were successfully launched during the period. Four satellites namely, South Asia Satellite (GSAT-9), GSAT-6, GSAT-19 & GSAT-6A, were launched using ISRO's launch vehicle and balance four satellites (GSAT-15, GSAT-16, GSAT-17 and GSAT-18) were launched using Procured Launches. South Asia Satellite was realized with the objective of providing communication services over **South Asian countries.**
- b) **Satellite Navigation Constellation:** Seven more satellites of the Indian Regional Navigation Satellite System (IRNSS) constellation were successfully launched during the period. The constellation is named as '**NavIC**', and dedicated to the nation by Honorable Prime Minister on 28th April 2016. IRNSS-1I is the eighth member to join the constellation, was launched successfully onboard PSLV-C41 on April 12, 2018.
- c) **Earth Observation Satellites:** The above period also witnessed the launch of seven Earth Observation satellites, viz., 4 high resolution imaging satellites (Cartosat-2 Series), advanced weather monitoring satellite (INSAT-3DR), satellite for cyclone tracking, climate and environmental studies (SCATSAT-1) with Ku-band Scatterometer, and a remote sensing satellite for natural resources management (Resourcesat-2A).

2. Space Science Missions

- a) **ASTROSAT:** India's first multi wavelength observatory capable of simultaneously viewing the Universe in the visible, Ultra-Violet and X-ray regions of the electromagnetic spectrum, with its 5 payloads, was successfully launched into its planned orbit. These payloads were realized through active participation of leading R&D institutions in the country. ASTROSAT has already made several important observations and 60 research papers have been published in peer reviewed journals.
- b) **Mars Orbiter Mission (MOM):** India's first inter-planetary mission MOM, far outliving its originally planned life, completed three years in its orbit, in September 2017. The health parameters of the spacecraft are normal, and all the five payloads are sending useful data. The Mars Colour Camera has, so far, produced around 940 images, one of which has appeared on the cover page of the November 2016 issue of the National Geographic Magazine.

3. Space Applications

3.1 SATCOM & SATNAV Applications

- Doordarshan is presently operating 34 satellite channels and has a vast network of 67 Studios and 1,409 Transmitters installed throughout the country. In terrestrial mode, DD1 (National) Channel coverage is estimated to be available to about 92% population of the country.
- Apart from Doordarshan, the public broadcaster, 6 private DTH operators are providing service in India. It is estimated that (TRAI Report - September 2017) there are about 65.31 million active DTH subscribers and about 883 TV channels are beamed in India as on June 2017.
- **Telecommunication:** Presently, 1404 Satellite Earth Stations of different size are operating in the satellite network of BSNL, Government users, closed user group, commercial users and broadcasters and are being utilised for telecommunications / broadcasting applications. About 2,74,000 VSATs are being used in star / mesh connectivity of various size and capabilities.

- **Telemedicine:** Presently about 130 Telemedicine nodes are operational across the country. An MOU is entered into with Ministry of Health and Family Welfare for operations and establishment of telemedicine nodes, in 2016. During the past 4 years, 19 new telemedicine nodes were established and 20 nodes were re-operationalized. Satellite connectivity was extended to mobile telemedicine vans of Sanjay Gandhi Post Graduate Institute, Lucknow and Shankara Cancer Center, Bengaluru. In association with Integrated Defence Staff (IDS-Medical) a new telemedicine node was established in Leh/Siachen region for the benefit of Army.
- **Tele-education:** At present around 44 Tele-education networks are operational in Haryana, Punjab, Chhattisgarh, Andhra Pradesh, Telangana, Kerala, Karnataka, Gujarat, Tamilnadu, Maharashtra and Rajasthan. About 300 satellite interactive terminals are made operational identified schools and colleges in the North Eastern States and 43 terminals in the Jammu & Kashmir. A dedicated satellite communication network is being established in association with Ministry of Skill Development and Entrepreneurship. Actions are in progress for establishing a tele-education network for Uttar Pradesh.
- **Specific Mobile App based application** for disseminating alert messages to Fishermen community through NavIC has been successfully developed and demonstrated. Initially 500 NavIC devices in Kerala and 200 NavIC devices in Tamil Nadu are planned to be distributed to fishermen by May 2018. Industries has been developed for mass production of Navic devices.

3.2 Earth observation & geo spatial applications

- **Horticulture Inventory:** Area assessment of 7 major horticultural crops (Potato, Onion, Tomato, Chili, Mango, Banana & Citrus) in about 185 districts spread over 12 States. Expansion of horticulture crops (pineapple, grapes, orange) particularly in under-utilized areas in north-eastern regions.
- Under Sericulture Development project, new potential areas have been identified for expansion of all four types of sericulture viz., mulberry, muga, eri and tasar in 41 districts in NE region. The value added maps have been extensively used for expansion activities of silkworm host plants and about 8000 ha of new plantations of mulberry host plants have been taken up in NER.

- Sustainable water bodies mapped for 177 tribal districts of the country for supporting aquaculture as an alternate livelihood.
- 3 cycles (2014-2017) of land use / land cover mapping on 1:250K scale and second cycle (2015-16) land degradation mapping on 1:50K scale have been completed.
- Mapping of degraded & wastelands completed for enabling crop intensification, afforestation and enhancing land productivity in the rural areas.
- Satellite data derived digital atlases of solar, offshore wind & wave energy potential have been generated. Estimation of Solar energy potential for nearly 98 SMART cities and 60 SOLAR cities has been carried out. 48-Hour solar energy forecast (at 15 Minute interval) and Mobile App for assessing location-specific Solar & Wind Energy potential developed.
- Fodder crop assessment in Gujarat, Rajasthan and Haryana for dairy industry at state level.
- Post kharif rice fallow assessment & suitability for growing pulse crops in rabi season for six Eastern States Bringing Green Revolution to Eastern India (BGREI).
- Ground Water Prospects maps prepared for the entire country. During 2016, nearly 100 wells were drilled in Karnataka and during 2017, 538 aquifer zones were identified in Tamil Nadu, to augment drinking water supply.
- Remote Sensing images in conjunction with geospatial tools are being used for creating large scale geo-spatial database for urban planning and enabling Urban Local Bodies for master plan preparation for 500 cities/towns under AMRUT programme.
- Bhuvan Ganga portal developed with more than 65 geospatial layers. Bhuvan Ganga Mobile app used to geotag more than 650 pollution sources across River Ganga
- Geo-MGNREGA: Geotagging of assets under MGNREGA. More than 2.82 Crore assets geotagged
- Integrated Watershed Management Programme - 86,000 micro-watersheds being monitored online; more than 8.67 lakh field photographs of development activities uploaded.

- Pradhan Mantri Awas Yojna (PMAY) - Geo-tagging of the beneficiary houses at different stages of construction. Currently about 15.23 lakh houses have been geo-tagged in 29 States.
- Inventory completed for all notified 3658 nationally important archaeological heritage sites & monuments demarcating management zones viz. Prohibited, Protected & Regulated zones. Towards Ease of doing business, a customized mobile application is developed to enable M/o Culture for online processing of Citizen Requests for granting No Objection Certificate.

3.3 Disaster Management Support

- The accurate early warning of cyclones viz. Hudhud (Oct 2014), Nilofar (Oct 2014), Roanu (2016), Kyant (2016), Vardah (Dec 2016) has immensely helped in saving the lives of people. Two more satellite, INSAT-3DR (providing half hourly images) & SCATSAT-1 (providing ocean surface wind vectors) launched to further improve accuracy of cyclone predictions.
- Active forest fire alerts (daily 6 observations) are being disseminated to State forest officials. On an average, nearly 34,600 forest fire detections were done during 2016-2017.
- Flood maps were provided for flood affected states during the monsoon season. Flood Early Warning System (FLEWS) is one of the operational programmes taken up by NESAC at the behest of Assam State Disaster Management Authority (ASDMA). FLEWS developed for 27 districts of Assam has been providing actionable product and flood alerts for effective management of floods.
- Seasonal Landslide inventory completed for 13 states. For the recent rainfall event (Jun-July, 2017) in NER, about 10000 new landslides mapped. Early warning for landslides is live in Bhuvan for the three regions (Uttarakhand, HP and NER)
- Under the International Charter on Space and Major Disasters, IRS data products were provided for 59 disaster events from 23 countries.

4. Technology/Infrastructure Development

- Establishment of First Indigenous Titanium sponge plant of capacity 500Tons per

annum at Chavara in Kerala.

- Establishment of Hafnium sponge plant of capacity 320kg per annum at Centre for Materials for Electronics Technology (C-MET), Hyderabad.
- Developed Technologies for tracking multiple objects in space with the establishment of Multi-Object Tracking radar at SDSC, Sriharikota.
- Commissioning of world's third largest hypersonic wind tunnel at Vikram Sarabhai Space Centre, Thiruvananthapuram.
- Indigenous development of 4.5ton Vertical Planetary Mixer, 40m³ liquid hydrogen storage tank and Telemetry & Telecommand Processor.
- Establishment of integrated multi-mission ground segment for earth observation satellites at NRSC, Hyderabad.
- First Indigenously developed Polarimetric Doppler Weather Radar installed at Cherrapunjee, dedicated to nation by the Hon'ble Prime Minister of India.
- Development of cost effective Finite Element Software for structural analysis named FEAST as a substitute for many proprietary structural analysis software developed by multinational companies.
- Establishment of the state-of-art advanced ground station for Earth Observation satellites at Bharti station, Antarctica for receiving Indian Remote sensing satellite (IRS) data.
- Demonstration of restart of upper stage liquid engine (PS4) of PSLV to enable injection of satellites into multiple orbit.
- Development and demonstration of six-meter diameter S-band Unfurlable Antenna for communication satellite (GSAT-6).
- Indigenous development of Lithium-ion battery (1.5Ah, 5Ah, 50Ah and 100Ah) for space application at Vikram Sarabhai Space Centre, Thiruvananthapuram.
- Indigenous development of Titanium (Ti5Al2.5Sn-ELI) alloy.
- development of Travelling Wave Tube Amplifier for Space borne payloads by Space Application Centre, Ahmedabad.
- Establishment of 30MHz radar system, Ionospheric Radar Interferometer at National Atmospheric Research Laboratory, Gadanki for ionospheric, meteor & space weather research in a comprehensive way.
- State-of-art vicarious Cal/Val (Calibration/Validation) site is set up for calibration of

satellite sensors at Shadnagar campus of NRSC.

- Establishment of a state-of-art Hot Isostatic Press (HIP) facility at Vikram Sarabhai Space Center, Thiruvananthapuram for processing of ceramic and high temperature materials through powder metallurgy route. This is the first HIP facility in the country in terms of capability.
- Multi Application Solar Telescope (MAST), a telescope for the detailed study of the solar activity including its magnetic field, operationalized at the Udaipur Solar Observatory of Physical Research laboratory.
- Design, development and successful demonstration of 18mN Stationary Plasma Thrusters (SPTs) in GSAT 9 communication satellite.

5. International Co-operation

- ISRO/ India signed **42 space cooperation** documents (Agreements, MoUs/ Implementing Arrangements) with **18 Countries/ space agencies**, viz, Afghanistan (1), Armenia (1), Australia (2), Bangladesh (1), Brazil (2), Canada (2), China (2), France (5), Israel (4), Japan (4), Kuwait (1), Mexico (1), the Netherlands (1), Portugal (1), Russia (2), UAE (1), USA (10) and Viet Nam (1).
- Joint Missions:
 - ❖ Feasibility studies for possible joint missions are initiated with France (Thermal Infra-Red - **TRISHNA** mission) and Japan (lunar exploration mission).
 - ❖ **NISAR**: Space Agencies of India and USA have made significant progress towards realising a joint satellite mission for earth science studies named NASA-ISRO Synthetic Aperture Radar (NISAR).
- Scientific Instrument in ISRO's Satellite
 - ❖ Technical documents are finalized for accommodating France's ARGOS instrument in India's OCEANSAT-3 satellite.
 - ❖ ISRO and Canadian Space Agency (CSA) have jointly realised Ultra Violet Imaging Telescope (UVIT) that was accommodated as one of the five scientific instruments in India's astronomy satellite 'ASTROSAT' (launched on September

28, 2015).

- Joint Experiments
 - ❖ Airborne campaign with NASA's hyperspectral instrument and ISRO's aircraft was conducted in selected sites over India to collect valuable data for Earth science research activities during December 2015-March 2016. Phase 2 of this experiment is current on, since March 2018.
 - ❖ Indian and French scientists are conducting Ka-band propagation experiment using signals from ISRO's GSAT-14 satellite and french instruments
 - ❖ Activities are on to carry out calibration/ validation experiment through data collection using India's RISAT-1 and Canada's RADARSAT-2.
 - ❖ Measuring Aerosol with NASA instruments in India through Balloon campaign in August 2017.
 - ❖ Conducting radio occultation studies in Venus atmosphere along with JAXA (Akatsuki mission) using IDSN
- Significant progress has been made in implementing 'India- Association of South East Asian Nations (ASEAN) space cooperation project', which will enable sharing of data from Indian satellites with ASEAN member nations for variety of applications including disaster management support and also to provide training in space science, technology and applications.
