भारत सरकार
अंतरिक्ष विभाग

सत्यमेव जयते

GOVERNMENT OF INDIA
DEPARTMENT OF SPACE

वार्षिक रिपोर्ट

ANNUAL REPORT
2021-2022

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Citizens' Charter of
Department of Space

Department of Space (DOS) has the primary responsibility of promoting the development of space science, technology, and applications towards achieving self-reliance and facilitating all-round development of the nation. With this primary objective, DOS has evolved the following programmes:

- Indian National Satellite (INSAT) programme for telecommunication, television broadcasting, meteorology, developmental education, societal applications such as tele-medicine, tele-education, tele-advisories, and similar such services
- Indian Remote Sensing (IRS) satellite programme for the management of natural resources and various developmental projects across the country using space-based imagery
- Indigenous capability for the design and development of satellite and associated technologies for communications, navigation, remote sensing, and space sciences
- Design and development of launch vehicles for access to space and orbiting INSAT/ GSAT, IRS and IRNSS satellites and space science missions
- Research and development in space sciences and technologies as well as application programmes for national development

The Department of Space is committed to:

- Carrying out research and development in satellite and launch vehicle technology to achieve total self-reliance
- Establish and maintain national space infrastructure for telecommunications, broadcasting, and navigation needs of the country
- Provide satellite services required for weather forecasting, monitoring, etc. and satellite imagery required for the natural resources survey, management of natural disasters, public good services, and monitoring of the environment in the country
- Offer Space-based services for developmental purposes through Central Government, State Governments, Quasi-Governmental Organisations, Non-Government Organisations (NGOs), and the private sectors
- Undertake demonstration of innovative missions in space science, technology, and applications
- Promote research in space sciences and development of applications programmes as per national needs

While implementing the above objectives, the Department of Space will:

- Provide the required satellite transponders and facilities to meet the communications, television broadcasting, and security requirements of our country
- Provide adequate earth observation capability in various spectral, spatial and temporal domains
- Provide launch services to meet national requirements and commercial needs
- Provide its products and services promptly and efficiently to all the users/clients

Contents

Space Missions
(As per Financial Year)

Mission	2020-2021	2021-2022	2022-2023
Earth Observation Satellites	1	2*	1
Communication Satellites	1	0	2
Navigation Satellites	0	0	1
Space Science Satellites	0	0	3
Technology Demonstrator	0	0	1
PSLV	3	1*	5
GSLV MkII	0	1	2
GSLV MkIII	0	0	1
Small Satellite Launch Vehicle	0	0	2
Gaganyaan	0	0	1
TOTAL	5	4	19

*Including the missions expected to be achieved by March 2022

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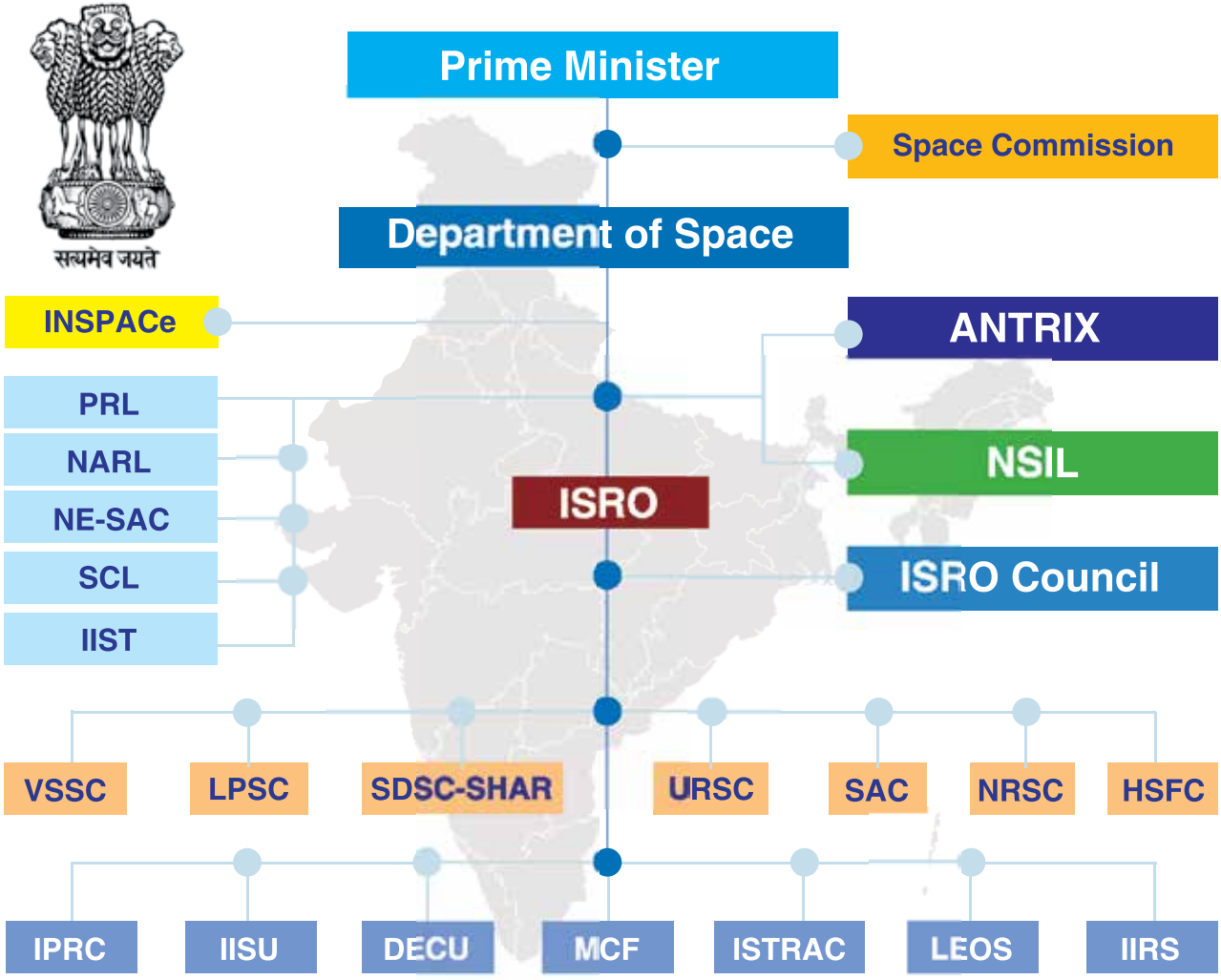
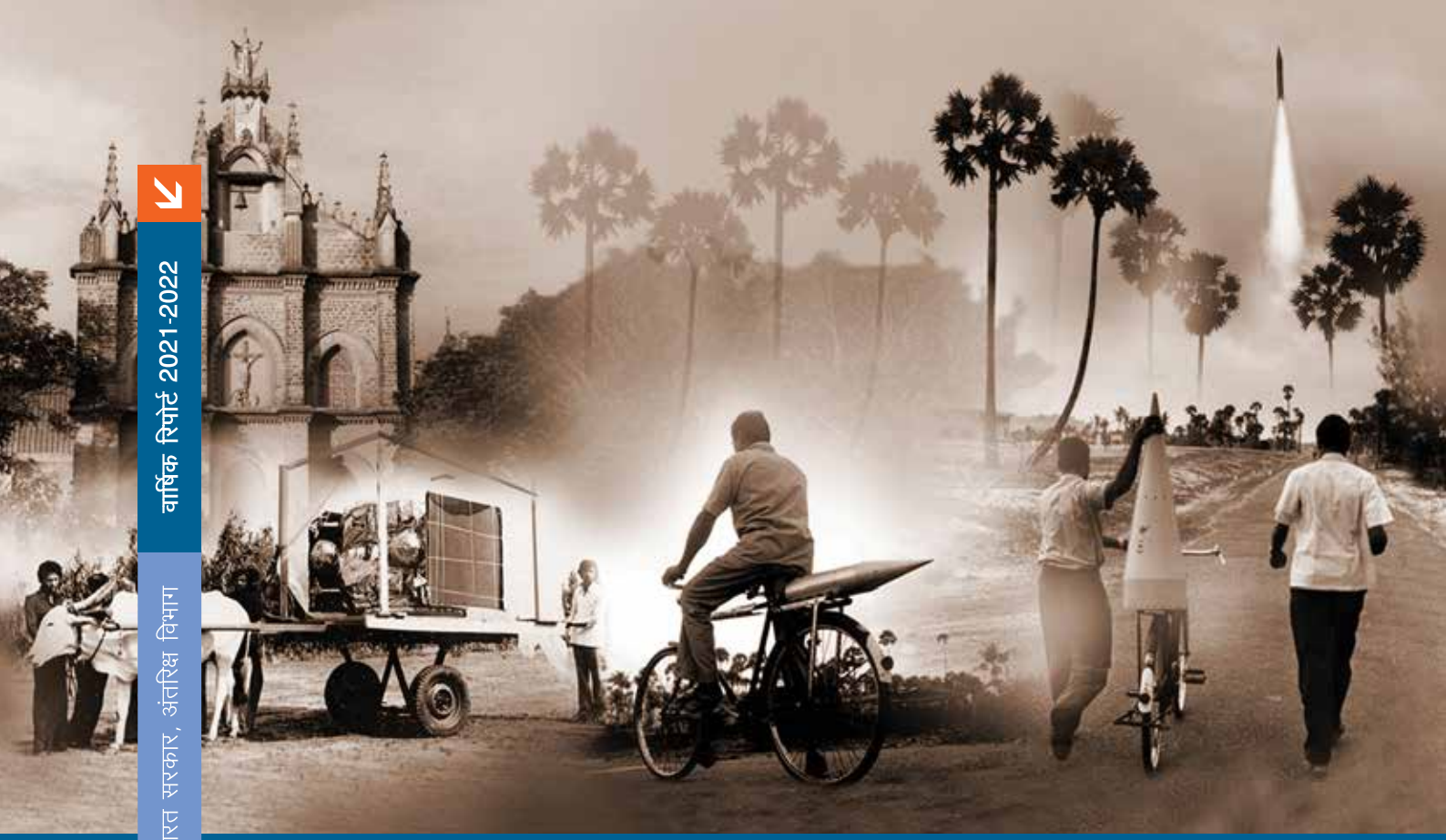
Organisation Chart



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
INSPACe	Indian National Space Promotion and Authorization Center
Antrix	Antrix Corporation Limited
NSIL	NewSpace India Limited
VSSC	Vikram Sarabhai Space Centre
LPSC	Liquid Propulsion Systems Centre
SDSC	Satish Dhawan Space Centre
URSC	U R Rao Satellite Centre
SAC	Space Applications Centre
NRSC	National Remote Sensing Centre
HSFC	Human Space Flight 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-Optics Systems
IIRS	Indian Institute of Remote Sensing



Space activities in the country were launched with the setting up of Indian National Committee for Space Research (INCOSPAR) in 1962. Work on Thumba Equatorial Rocket Launching Station (TERLS) near Thiruvananthapuram was also started during the same year. In August 1969, the Indian Space Research Organisation (ISRO) was established. In June 1972, the Space Commission and the DOS were constituted by the Government of India (GoI) and brought ISRO under DOS in September 1972.

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, ISRO, Physical Research Laboratory (PRL), National Atmospheric Research Laboratory (NARL), North Eastern-Space Applications Centre (NE-SAC), and Semi-Conductor Laboratory (SCL). Antrix Corporation Ltd. and NewSpace India Limited, Government-owned Public Sector Units, are set up for commercialisation of R&D activities of DOS.

DOS Secretariat and ISRO Headquarters are located at Antariksh Bhavan in Bengaluru. Programme offices at ISRO Headquarters coordinate the programmes like satellite communication, earth observation, navigation, launch vehicle, space science, disaster management support, sponsored research scheme, Human Spaceflight, international cooperation, system reliability and quality, space situational awareness, safety, media & public relations, budget and economic analysis, human resources and capacity building. The major establishments of DOS and their area of activities are given in the following paragraphs:

VSSC Main Building at Veli Range Complex

VSSC

Vikram Sarabhai Space Centre (VSSC)

VSSC, Thiruvananthapuram is responsible for the design and development of launch vehicle technology. The Centre pursues active research & development and has developed core competence in various disciplines related to aerospace systems.

The major programmes at VSSC include Polar Satellite Launch Vehicle (PSLV), Geosynchronous Satellite Launch Vehicle (GSLV), Geo-Synchronous Satellite Launch Vehicle (GSLV) Mk-III, Rohini Sounding Rockets as well as the development of Small Satellite Launch Vehicle (SSLV), Reusable Launch Vehicle (RLV), Test Vehicle Project (TVP), air-breathing propulsion, and critical technologies towards human spaceflight Gaganyaan.

URSC Main Building

URSC

U R Rao Satellite Centre (URSC)

URSC, Bengaluru, is the lead Centre for design, development, the realisation of communication, navigation, remote sensing, scientific and small satellite missions. The specialized teams of scientists, engineers, and technicians of URSC have built around 112 complex & advanced satellites for various applications in areas of telecommunications, television broadcasting, VSAT services, telemedicine, tele-education, navigation, weather forecasting, disaster warning, search and rescue operations, earth observations, natural resource management, scientific and space science etc.

URSC is also involved in research and development activities of cutting-edge satellite technologies, total management of all satellite missions, creation of a vibrant space industry to realize space systems, technology transfer, academia interface, etc. The Centre also houses ultra-modern design, development, fabrication, and testing facilities for satellites.

URSC operates from its 32 acre main campus, HAL Airport Road, and 110 acre ISRO Integration & Testing Establishment (ISITE) campus at Marathahalli, 8 km away from the main campus.

URSC's second campus, ISRO Satellite Integration and Test Establishment (ISITE) established in 2006, is equipped with facilities for the complete assembly and test sequence that can enable rolling out of a flight-worthy spacecraft from the stage of a basic structure. It is replete with integration and environmental test facilities under one roof, namely two large clean rooms and associated Ground Checkout systems for spacecraft assembly, integration and testing, Compact Antenna Test Facility, Comprehensive Assembly, and Test Vacuum Chamber, Comprehensive Assembly & Test Vibration Facility, Acoustic Test Facility etc.

Satish Dhawan Space Centre (SDSC) SHAR

SDSC

Satish Dhawan Space Centre (SDSC) SHAR

SHAR, the "Spaceport of India," is the backbone of the ISRO in providing launch base infrastructure for the Indian Space Programme.

During the present year, all the launch complex facilities are activated and utilised to ensure timely supply of production deliverables and precise accomplishment of activities to match with the varying needs of ISRO's Launch Vehicle and Satellite communities and also the foreign satellite customers.

LPSC, Bengaluru

LPSC

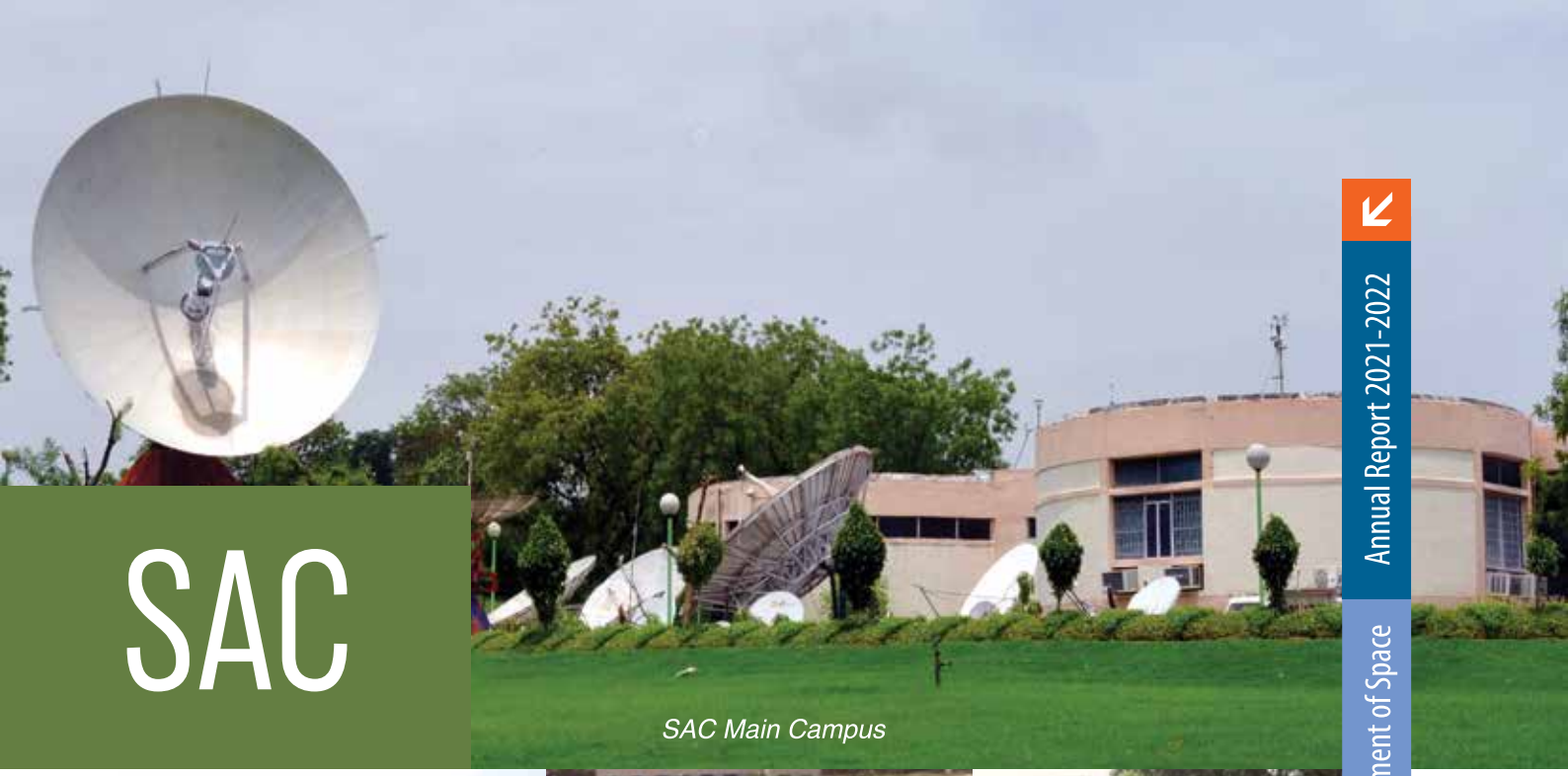

LPSC, Valiamala

Liquid Propulsion Systems Centre (LPSC)

LPSC is the lead Centre of ISRO for the design, development, and realisation of advanced propulsion Systems for Launch Vehicles and also space propulsion systems for spacecrafts. LPSC is vested with the responsibility of design, development, and delivery of high-performance Space Propulsion Systems employing Earth Storable, Cryogenic, Semi Cryogenic, and Electric Propulsion Systems for ISRO launch vehicles and satellites.

LPSC activities and facilities are spread across its two campuses, namely, LPSC, Valiamala, Thiruvananthapuram, and LPSC, Bengaluru, Karnataka. The activities in its campus at Valiamala include design and development entities for earth storable, cryogenic, semi cryogenic, and electric propulsions systems. The end-to-end design, development, and realisation of flow control components and modules, advanced manufacturing and proto fabrication entities, project teams, management systems activities, as well as R&D activities in the area of propulsion and structure are carried out by expert entities. LPSC activities in its campus at Bengaluru include the design and realisation of propulsion systems for remote sensing and communication satellites and other scientific missions. Also, the development and production of transducers and sensors are undertaken here.

SAC


SAC Main Campus


SAC New Bhopal Campus


SAC Bhopal Technical Campus


Delhi Earth Station

Space Applications Centre (SAC)

SAC is a major research and development Centre of ISRO. The core competence of the Centre lies in the development of space-borne and air-borne instruments/payloads and their applications for national development and societal benefits. These applications are in diverse areas and primarily meet the communication, navigation, and remote sensing needs of the country.

The communication transponders developed at this Centre for the INSAT and GSAT series of satellites are used by the government and private sector for VSAT, DTH, Internet, broadcasting, telephony services, etc.

SAC designs and develops optical and microwave sensors for the satellites, signal and image processing software, GIS software, and many applications for the Earth Observation (EO) programme of ISRO. These applications are in diverse areas of Geosciences, Agriculture, Environment and Climate Change, Physical Oceanography, Biological Oceanography, Atmosphere, Cryosphere, Hydrosphere, etc. SAC has highly competent Space R&D and hardware and software design teams, state-of-the-art electronic and mechanical fabrication facilities, sophisticated payload integration, climatic and environmental test facilities, systems reliability area, image processing, and analysis facilities, and project management teams. SAC also has a strong association with industry for sourcing, indigenisation & technology transfers and also engaged with Academia including Indian and foreign universities and colleges for collaborative research programs and for promotion of space technologies and applications amongst students and public through outreach programs such as in-house & mobile exhibitions, seminars, webinars, technical conferences.

HSFC

Human Space Flight Centre (HSFC)

HSFC was formed on January 30, 2019. As a lead Centre for human space flight activities, HSFC will undertake multi-disciplinary R&D activities in new domains of human science and technology while conforming to high standards of reliability and human safety. HSFC is currently concentrating on Gaganyaan mission with thrust on areas like end-to-end mission planning, development of Orbital Module (OM), development of Life support systems, selection and training of astronauts, development of various Training simulators, co-ordination in Recovery and rehabilitation of astronauts, collaboration with National and International agencies/institutions for multi-directional growth to act as a technology aggregator.

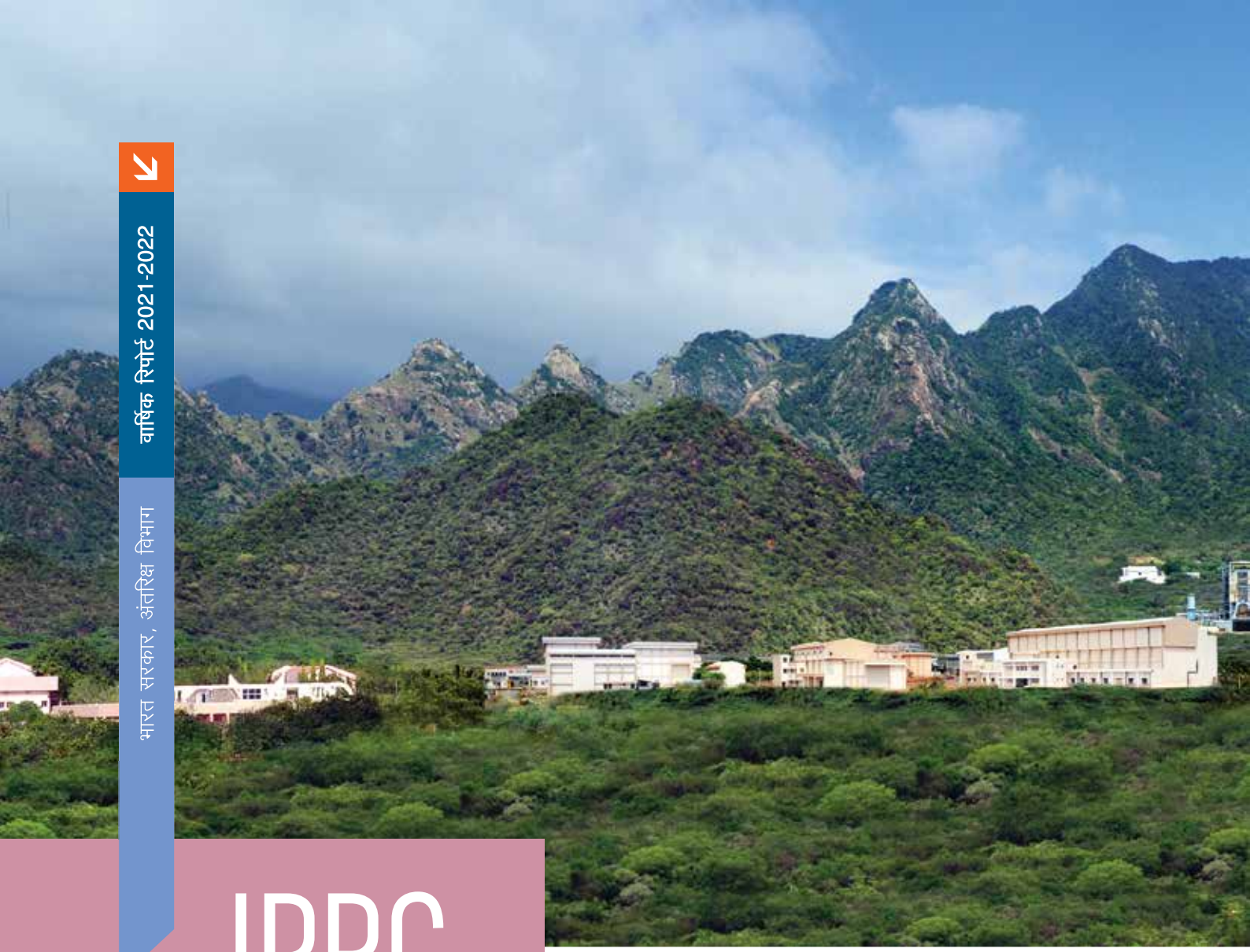
The Centre is currently operating in a temporary building in ISRO-HQ campus, Bengaluru, and the proposal for a full-fledged campus for the new centre is under approval. Apart from Gaganyaan, HSFC will focus in the future on new areas of technology development, significant amongst them includes nurturing and creating new expertise in the domains of Bioastronautics, Human space sciences, and Space habitat systems. The Centre will develop the necessary expertise to sustain the human space flight activities in the country, including the capability to build Orbiting space station and become active partners in collaborative interplanetary manned missions to Moon/Mars and near-Earth Asteroids.

NRSC

National Remote Sensing Centre (NRSC)

NRSC has the mandate for the establishment of ground stations for receiving satellite data, generation of data products, aerial remote sensing data acquisition, dissemination to the users, development of techniques for remote sensing applications including disaster management support, geospatial services for good governance and capacity building for professionals, faculty, and students.

NRSC operates through multiple campuses to meet national and regional geospatial needs. NRSC has three campuses at Balanagar, Shadnagar, and Jeedimetla in Hyderabad and five Regional Remote Sensing Centres (RRSCs) in Bengaluru, Jodhpur, Kolkata, Nagpur, and New Delhi for promoting remote sensing applications for various states. The main Campus at Balanagar, Hyderabad houses Administration, Remote Sensing Applications, and Aerial Services. The Campus at Shadnagar hosts the Integrated Multi-Mission Ground Segment for Earth Observation Satellites (IMGEOS) facility. The areas of Satellite Data Reception, Data Processing and Dissemination, Bhuvan Geoportal and Web Services, Earth and Climate Studies, and Disaster Management Support services operate from IMGEOS, Shadnagar. Bhuvan fare the geoportals of NRSC for the dissemination of satellite data and geo-spatial products and services in the country. Outreach facility at Jeedimetla in Hyderabad for providing training for professionals, faculty, and students and for general outreach. Aircraft operations facility at Begumpet Airport, Hyderabad.



IPRC

ISRO Propulsion Complex (IPRC)

IPRC, Mahendragiri is responsible for Assembly, Integration, and Testing of liquid propulsion systems for operational and developmental launch vehicles. IPRC is also responsible for the Qualification, Testing and Acceptance of Liquid engines, Cryogenic engines, spacecraft engines, and Thrusters, and also provides a platform for simulation trials for interplanetary missions. IPRC is equipped with state-of-art facilities necessary for realising the cutting-edge technology products for ISRO's space program.

DECU

Development and Educational Communication Unit (DECU)

Established in 1983, the 'DECU located at Ahmedabad, has been the focal unit of ISRO for implementation of satellite-based societal applications in the country. DECU is mainly involved in the system definition, planning, implementation, and social research & evaluation of such applications. To this end, it works with user agencies to experiment with innovative configurations to meet their requirements. It is through these application oriented experiments/demonstrations for communications, production of educational communication material, and joint working with end-users – with the 'end-to-end' approach - that DECU facilitates covering of the 'last mile' in space applications. The unit has been responsible for the conceptualisation and demonstration of many societal applications of satellite communications.

ISTRAC

ISRO Telemetry, Tracking and Command Network (ISTRAC)

ISTRAC, a unit of ISRO, is entrusted with the primary responsibility of providing TTC and mission control services to major Launch Vehicle and LEO and Interplanetary Spacecraft missions of ISRO. It has the additional responsibility of operating the complex Ground Segment of NavIC. ISTRAC is also undertaking the development of radar systems for launch vehicle tracking and meteorological applications, providing Search & Rescue and Disaster Management Services and supporting space-based services like tele-medicine, Village Resource Centres, and tele-education.

In order to realize these objectives, ISTRAC has established a network of ground stations, 5 stations at Bengaluru, 3 stations at Lucknow, 2 stations each at Mauritius, Sriharikota, Port Blair, Biak, 1 station each at Thiruvananthapuram, Brunei and the Indian Deep Space Network Stations IDSN-32 and two IDSN-18 (including new indigenous) terminals.

The Mission Operations Complex located at Bengaluru carries out round-the-clock mission operations for all remote sensing, science, and planetary mission. All network stations of ISTRAC are connected to the Mission Operations Complex through dedicated high-performance satellite communication links and/or terrestrial communication links.

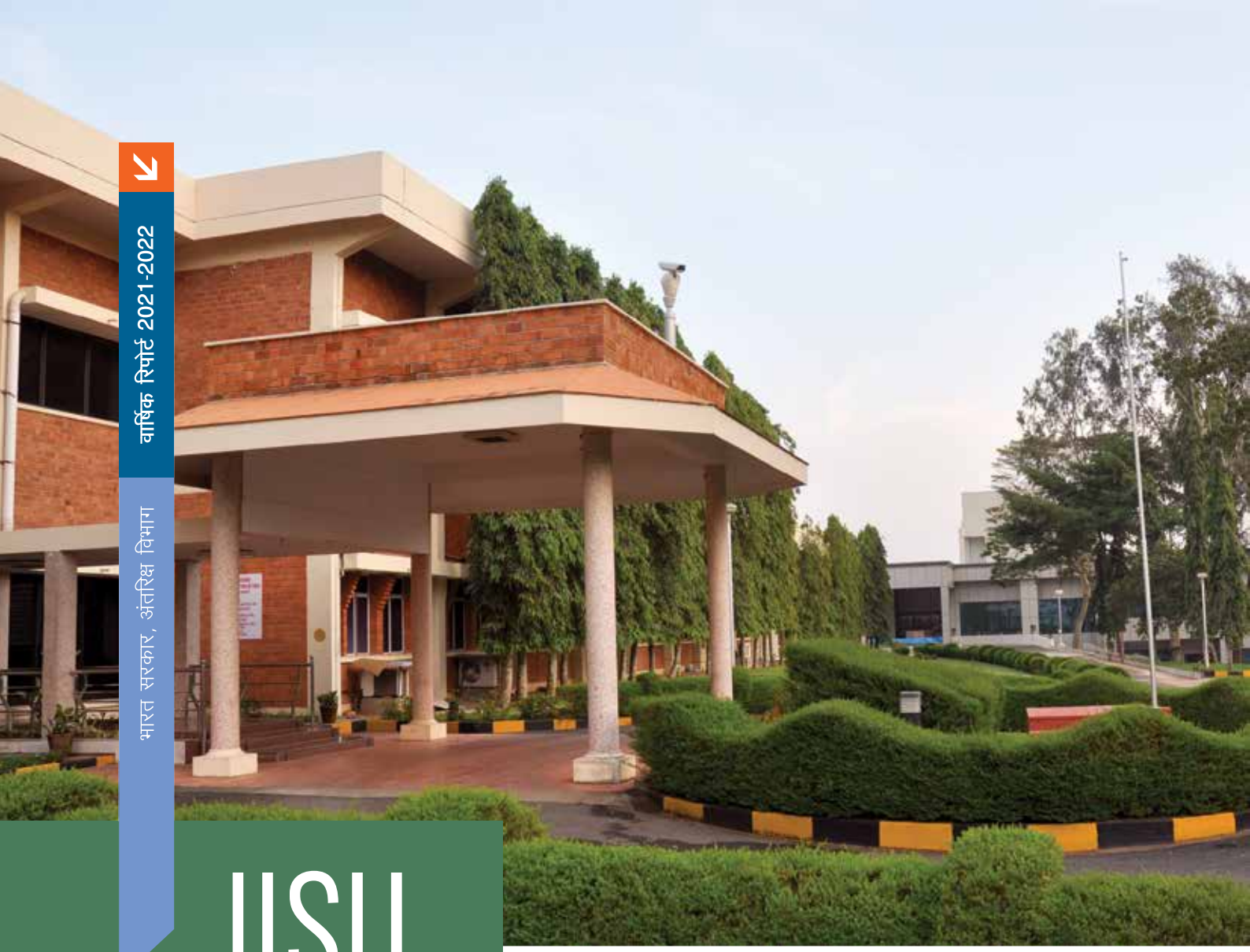
Under the NavIC Ground Segment, ISTRAC has established a network of stations consisting of 4 IRNSS CDMA Ranging stations (IRCDR) and 16 IRNSS Range and Integrity Monitoring stations (IRIMS). ISTRAC has also established the ISRO Navigation Centre-1 (INC-1), including an IRNSS Network Timing (IRNWT) facility at Bengaluru and ISRO Navigation Centre-2 (INC-2), including an IRNWT facility at Lucknow.

MCF

Master Control Facility (MCF)

MCF is responsible for On-Orbit Operations (OOP) and Launch and Early Orbit Phase (LEOP) operations of geostationary/ geosynchronous and IRNSS class of spacecraft of ISRO. Master Control Facility (MCF) at Hassan in Karnataka, with a Geo-arc visibility of more than 140°, is an ideal control center in the South Asian region.

The facilities located at Hassan and Bhopal together now take care of 29 Spacecraft (21 in GEOSAT class and 8 in IRNSS class) with payloads classified into communication, meteorological and navigational category. These satellites are placed between 32.50° E and 129.50° E are in 12 orbital slots, and most of them are collocated, scaling up payload capacity and optimum use of spectrum availability.



IISU

ISRO Inertial Systems Unit (IISU)

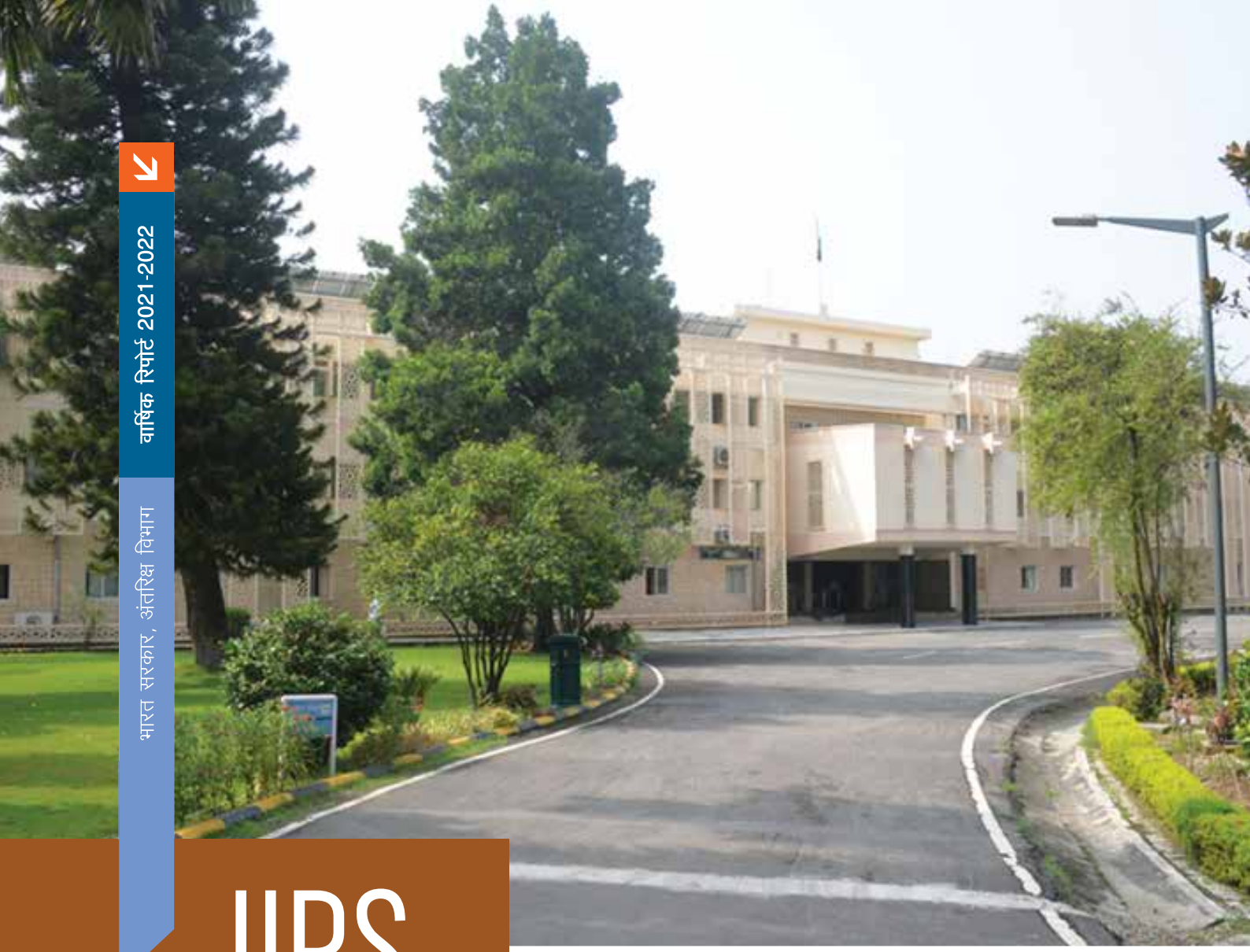
IISU, Thiruvananthapuram, is responsible for the design and development of Inertial Systems for Launch Vehicles and Satellites. Major systems like Inertial Navigation Systems based on mechanical gyros and optical gyros, Attitude Reference Systems, Rate Gyro Packages, Accelerometer Packages are developed indigenously and used in various missions of ISRO. IISU also designs and develops Actuators and Mechanisms, namely, Reaction Wheel, Momentum Wheel, Solar Array Drive, and Scan Mechanisms for spacecraft and allied applications. Presently, IISU is engaged in the process of consolidation and productionisation of the Sensors, Systems, Actuators, and Mechanisms for a variety of launch vehicle and spacecraft applications.

IISU is engaged in continuous Research and Development too. IISU has initiated advanced technology development programmes in niche areas focusing on miniaturisation, low power and cost, and scalable sensors and systems.

LEOS

Laboratory for Electro-Optics Systems (LEOS)

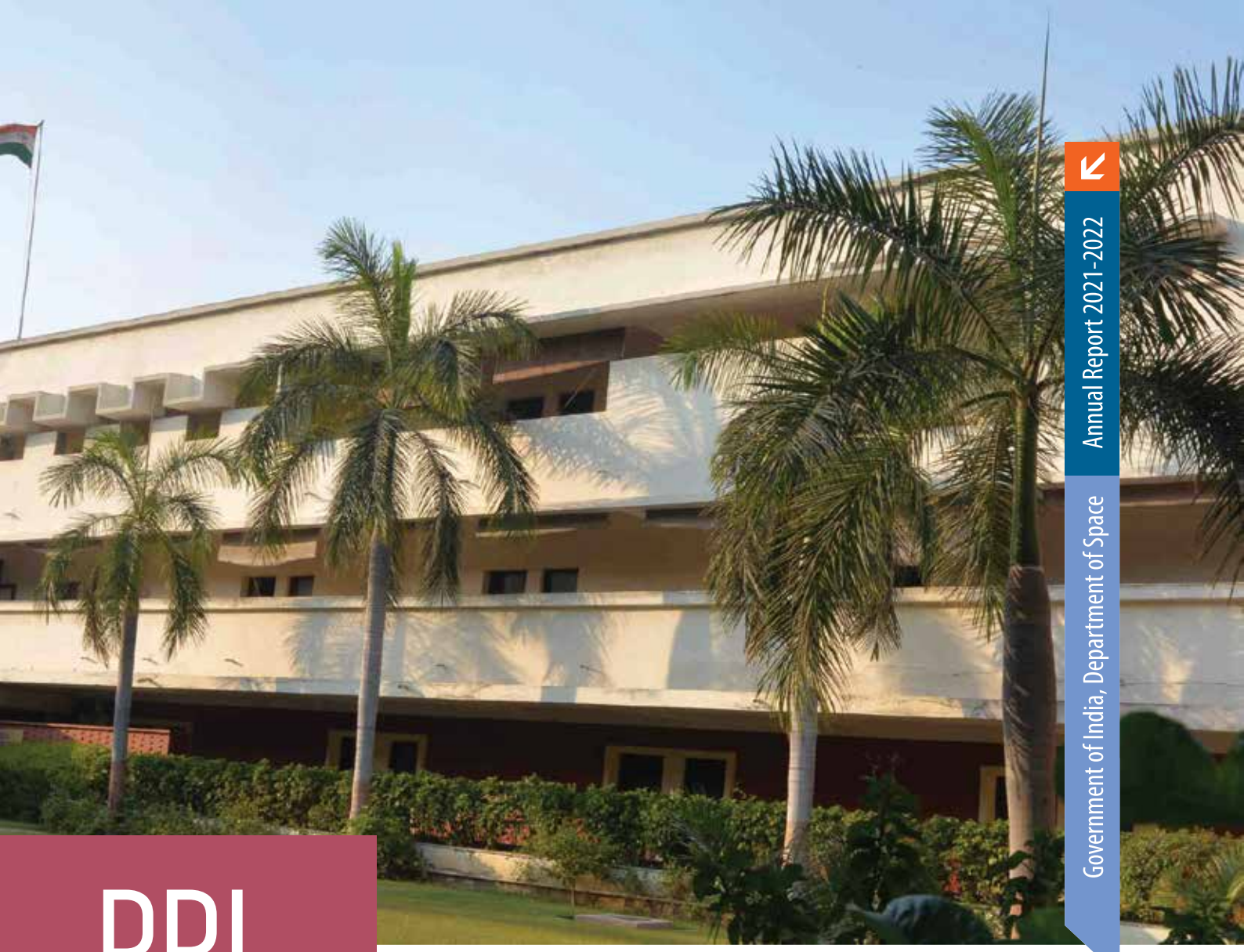
LEOS, Bengaluru, is the lead unit for the design, development, and production of attitude sensors, high-resolution imaging optics, and special purpose science instruments for several spacecrafts. Sensor systems include Star sensors, Earth sensors, Sun sensors, Magnetic sensors, Fiber optic gyro (FOG), Temperature sensors, and MEMS-based inclinometer. Optical systems include optics for remote sensing cameras, radiometers, sensors, optical filters, photo masks, optical coatings, IR detectors, Rad Hard UV Dosimeter, and THz photometers. Science payloads include Laser-induced break down spectroscopy (LIBS), MEMS Seismometer and specialized optics for payloads of Aditya–L1 (VELC and SUIT).



IIRS

Indian Institute of Remote Sensing (IIRS)

IIRS is a premier institute with a primary aim to build capacity in Remote Sensing and Geoinformatics and their applications through education and training programmes at the postgraduate level. It is a constituent Unit of ISRO. Formerly known as Indian Photo-Interpretation Institute (IPI), founded in 1966, the Institute is the first of its kind in entire South-East Asia. While nurturing its primary endeavor to build capacity among the user community by training mid-career professionals since its founding in 1966, the Institute has enhanced its capability and evolved many training and education programmes that are tuned to meet the requirements of various stakeholders, ranging from fresh graduates to policy makers including academia, industry, and NGOs.



PRL

Physical Research Laboratory (PRL)

PRL, Ahmedabad is an autonomous unit of DOS, and a premier research institute engaged in basic research in the areas of Astronomy and Astrophysics, Solar Physics, Planetary Science and Exploration, Space and Atmospheric Sciences, Geosciences, Theoretical Physics, Atomic, Molecular and Optical Physics and Astro-chemistry.

The primary mandate of the PRL is to carry out research, publish scientific papers and develop appropriate instrumentation to enable their specific science goals.

X-band radar building at NARL

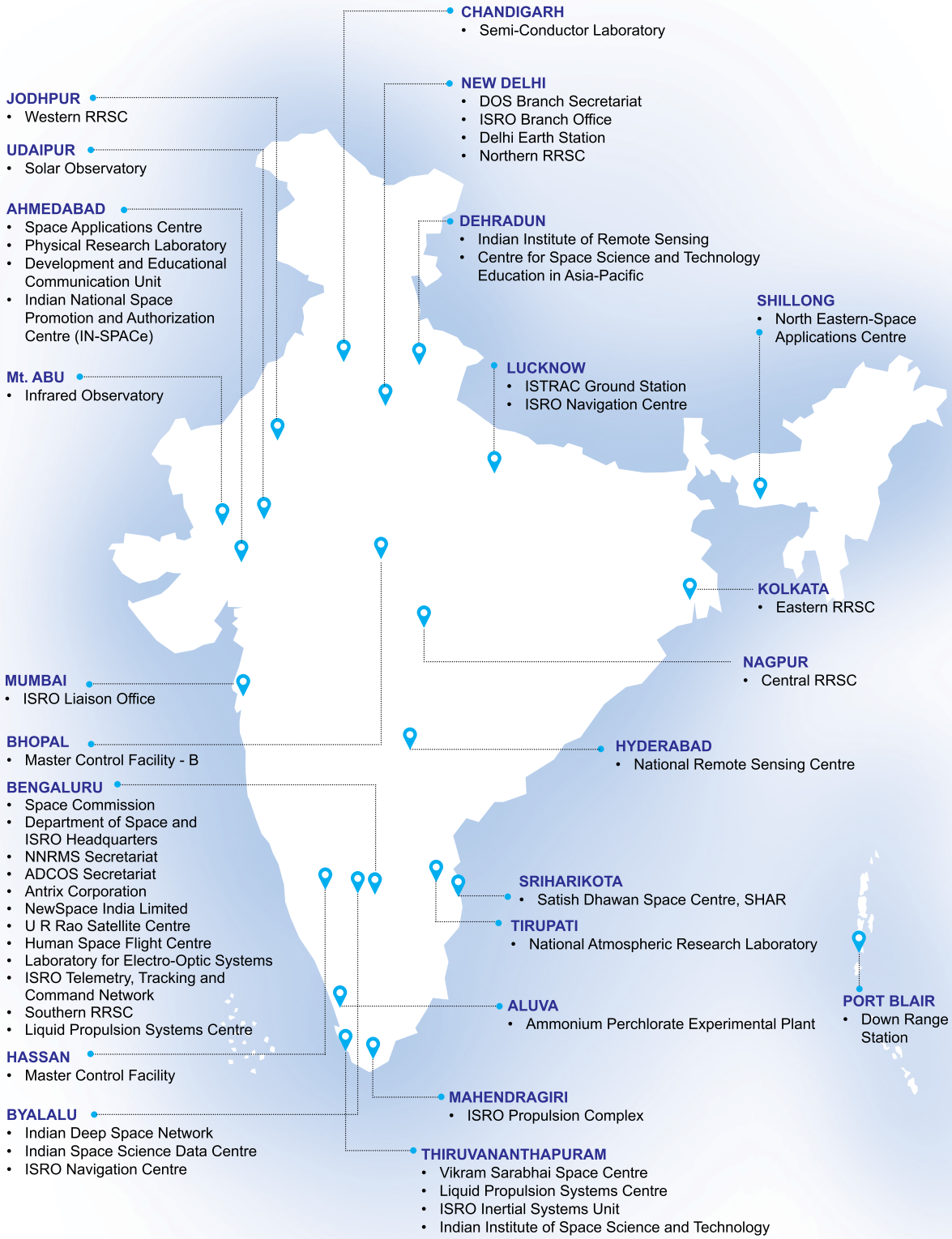
NARL

National Atmospheric Research Laboratory (NARL)

NARL, located at Gadanki near Tirupati, is an autonomous organisation engaged in cutting-edge research in atmospheric and space sciences with the vision of "Developing capability to predict the behavior of the earth's atmosphere through observations and modeling." Towards realizing this vision, NARL gives equal emphasis to technology development, observations, data archival and dissemination, data assimilation, and modeling.

NARL provides high-resolution data upper air winds and weather forecasts supporting rocket launches from SDSC, SHAR. NARL has a vibrant research program, capacity building, and public outreach activity.

Space Centres in India



NE-SAC

North Eastern-Space Applications Centre (NE-SAC)

NESAC is an autonomous organisation under the DOS and is a joint initiative of DOS and the North Eastern Council (NEC). The centre has the mandate to provide space-based support in governance and development by taking up projects in the fields of natural resources management, infrastructure planning, healthcare, education, emergency communication, disaster management support, atmospheric science research, etc. The centre also conducts training and capacity building in the field of geospatial technology and unmanned aerial vehicle-based remote sensing applications. The Centre coordinates with the State Remote Sensing Application Centres of the North Eastern Region (NER) and acts as a nodal center for the implementation of major national and regional programmes requiring space-based inputs. During the FY 2021-22, NESAC has completed a number of application projects sponsored by the user agencies and taken up research and development projects under the Earth Observation Application Mission, Disaster Management Support Program, and ISRO Geosphere-Biosphere Programme. The Centre has provided more than 21 years of dedicated service for the holistic development of the NER of India.

SCL

Semi-Conductor Laboratory (SCL)

SCL is engaged in providing end-to-end solutions for the Development of Application Specific Integrated Circuits (ASICs), Opto-electronics Devices, and Micro Electro Mechanical systems (MEMS) Devices encompassing Design, Fabrication, Assembly, Packaging, Testing, and Reliability Assurance. SCL has 180nm CMOS Technology on 8" Wafer Fab Line as per international standards and has a 6" Wafer Fab Line with CMOS/MEMS process capability. The efforts at SCL are directed towards creating a strong microelectronics base with activities focused on the realisation of critical and high-reliability device requirements of DOS/ISRO Centres & Units and other users.

The operations at SCL also include fabrication of Hi-Rel Boards, Radio Sonde Systems, and indigenisation of electronic sub systems.

IIST

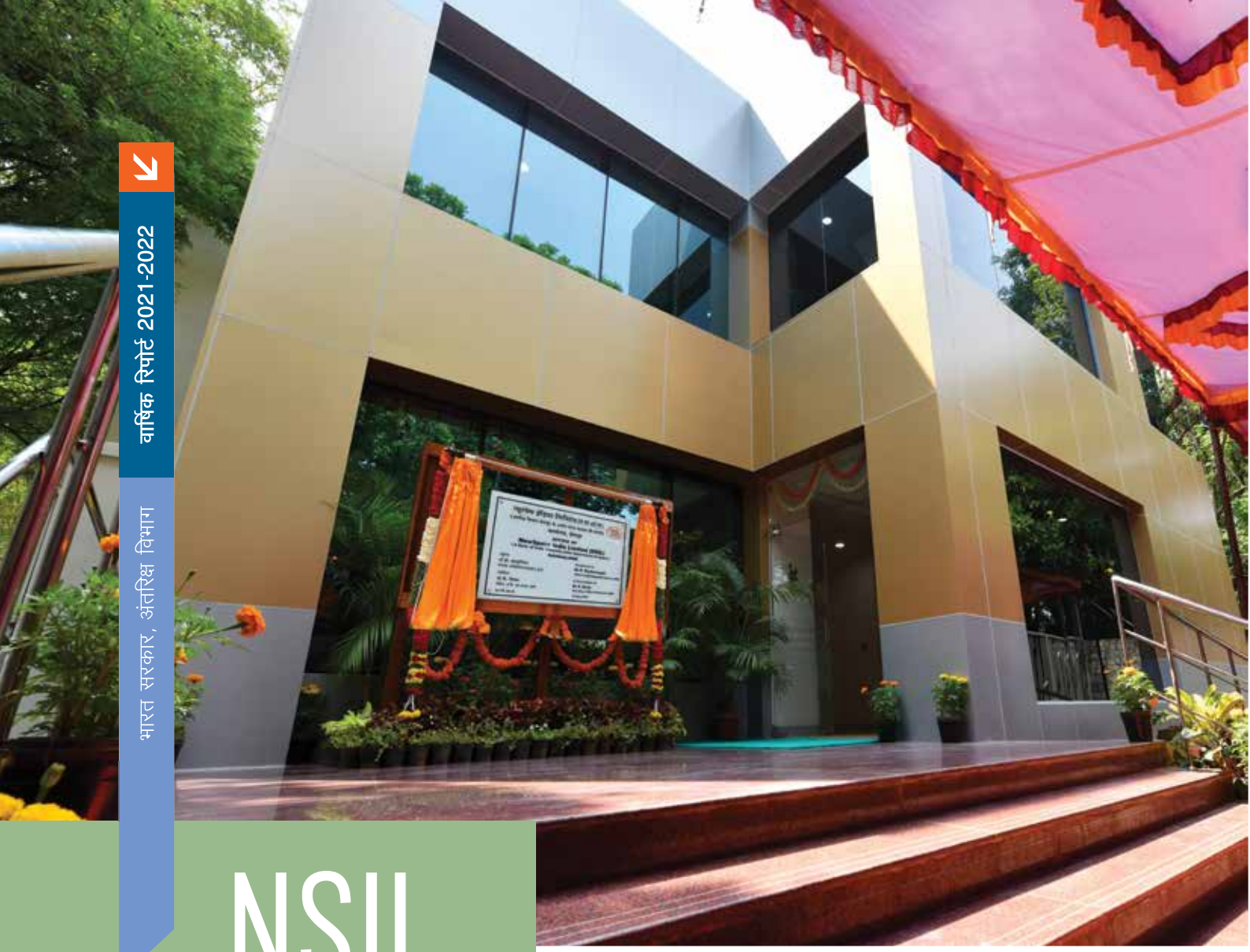
Indian Institute of Space Science and Technology (IIST)

IIST, Asia's first Space University, was established at Thiruvananthapuram in 2007 to offer high-quality education in space science and technology to meet the demands of the Indian Space Programme. The institute offers undergraduate, postgraduate, doctoral, and post-doctoral programmes in broad areas of space science, technology and applications. The institute is committed to excellence in teaching, learning and research. IIST fosters state-of-the-art research and development in space studies and provides a think-tank to explore new directions for the Indian Space Programme.

ACL

Antrix Corporation Limited (ACL)

Antrix Corporation Limited, Bengaluru is a wholly-owned Government of India entity under the administrative control of DOS. Antrix is engaged in providing Space products and services to international customers worldwide, ranging from supply of hardware and software, remote sensing data services, transponder lease services, launch services, mission support services, and other allied services.



NSIL

New Space India Limited (NSIL)

NSIL got incorporated on March 06, 2019, as a wholly-owned Government of India Undertaking/Central Public Sector Enterprise (CPSE), under the administrative control of the DOS. NSIL has been categorized as Schedule 'A' CPSE by the Dept. of Public Enterprises (DPE) on February 06, 2020.

The government of India enhanced the role and scope of NSIL to encompass more responsibilities in the primary business areas and widen the scope in June 2020. The revised mandate broadly covers (i) Owning satellites for Earth Observation and Communication applications; (ii) Providing space-based Earth Observation and Communication services; (iii) Building satellites and launching them as per demand; (iv) Building launch vehicles through Indian Industry and launch as per requirements; (v) Providing launch services and (iv) Technology Transfer to Indian Industry.

IN-SPACe

Indian National Space Promotion and Authorization Centre (IN-SPACe)

As the space sector was opened up to private enterprises and start-ups to undertake space activities to promote, handhold, regulate and authorise their activities, an independent nodal agency under DOS - the Indian National Space Promotion and Authorization Centre (IN-SPACe) was formed. This will enhance the diffusion of space technology and boost the space economy within the country.

IN-SPACe will permit and oversee the activities of private enterprises and start-ups. It regulates space activities, including the building of launch vehicles and satellites and providing space-based services as per the definition of space activities. It permits the sharing of space infrastructure of ISRO and the establishment of temporary facilities within the premises of ISRO. It promotes the establishment of new space infrastructure and facilities, by Non-Government Private Entities (NGPE), in pursuance of space activities based on safety norms and other statutory guidelines and necessary clearances. IN-SPACe governs the usage of spacecraft data and rolling out of space-based services and all the associated infrastructure for the same. IN-SPACe would operate with its headquarters in Ahmedabad and field officers in Bengaluru and Mumbai.

2

Major Activities

2.1 Earth Observation, Meteorological Satellite System and Applications

2.1.1 Programme

Operational remote sensing services were initiated with the launch and commissioning of IRS-1A, the first operational Indian Remote Sensing (IRS) Satellite, in 1988. Various instruments onboard IRS satellites provide data in varied spatial, spectral and temporal resolutions to cater to different user requirements in the country. The INSAT series of satellites, with meteorological payloads operating from geostationary orbit, provide data for generating various parameters, namely, cloud motion vectors, cloud top temperature, water vapour content, vertical profiles of temperature and humidity and facilitate weather forecasting, the genesis of cyclones and their track prediction, etc.

2.1.2 Earth Observation Satellites in Service

Resourcesat-1 is the tenth satellite of ISRO in IRS series, intended to not only continue the remote sensing data services provided by IRS-1C and IRS-1D, both of which have far outlived their designed mission lives, but also to vastly enhance the data quality. Resourcesat-1 is the most advanced Remote Sensing Satellite built by ISRO as of 2003. It was launched by PSLV-C5 into 817 km Sun Synchronous orbit on October 17, 2003. It has three optical remote sensing payloads, namely LISS-3, LISS-4, AWiFS-A and AWiFS-B with the enhanced multispectral resolution of LISS-4 with 3 bands, LISS-3 operating in 4 bands and AWiFS operating with 4 bands split as two modules AWiFS-A&B. This satellite has served beyond the designed mission life.

Cartosat-2, launched on January 10, 2007, onboard PSLV-C7, carries a single panchromatic camera with the capability to provide better than 1 m spatial resolution imagery with 9.6 km swath. The satellite can be steered along and across the track of up to ± 45 ° to facilitate frequent imaging of any specific area. The satellite has served beyond the designed mission life.

Cartosat-2A, launched on April 28, 2008 onboard PSLV-C9, carries a single panchromatic camera with the capability to provide better than 1 m spatial resolution imagery with 9.6 km swath. It was placed in a Sun-synchronous polar orbit at a nominal altitude of 635 km with a re-visit of 4-5 days. The satellite can be steered along and across the track of up to ± 45 degree to facilitate frequent imaging of any specific area. Imageries from this satellite are used for

2.1 Earth Observation, Meteorological Satellite System and Applications

cartographic applications like mapping, urban and rural infrastructure development and management, as well as application in Land Information (LIS) and Geographical Information System (GIS).

Radar Imaging Satellite-2 (RISAT-2), the X-band Synthetic Aperture Radar (SAR) satellite, was launched onboard PSLV-C12 on April 20, 2009. The satellite enables imaging of the surface features during both day and night under all weather conditions. RISAT-2 has enhanced the country's capability in disaster management support activities.

Oceansat-2, a follow-on mission to Oceansat-1, was launched on September 23, 2009 onboard PSLV-C14 into a polar Sun-synchronous orbit at an altitude of 720 km, with an equatorial crossing of 12:00 Hrs. Oceansat-2 carried three sensors onboard, namely, Ocean Colour Monitor (OCM), Ku-band pencil beam Scatterometer and a Radio Occultation Sounder for Atmospheric Studies (ROSA). The eight-band Ocean Colour Monitor provides data at 360 m spatial resolution of 1420 km swath with two-day receptivity. The data is used to generate Local Area Coverage (LAC) product of 360 m resolution (2-day coverage cycle) and Global Area Coverage (GAC) product of 1 km resolution (8-day coverage cycle). ROSA Payload, designed and developed by Italy, was flown in Oceansat-2 to study the temperature and humidity profile of the atmosphere. Both OCM and ROSA payloads are still providing data services.

Cartosat-2B, launched on July 12, 2012 onboard PSLV-15, carried a single panchromatic camera with the capability to provide better than 1 m spatial resolution imagery with 9.6 km swath. It was placed in a Sun-synchronous polar orbit at a nominal altitude of 630 km with a re-visit of 4-5 days. The highly agile Cartosat-2B is steerable up to ± 26 ° along as well as across track to obtain stereoscopic imagery and achieve a four to five-day revisit capability.

Resourcesat-2, a follow on mission to Resourcesat-1, provides data continuity to the Indian and global user community. It was launched by PSLV-C16 into an 817 km Sun synchronous orbit on April 20, 2011. As in Resourcesat-1, it has three optical remote sensing payloads, namely, LISS-3, LISS-4 and AWiFS with enhanced multispectral swath from 23 km to 70 km for LISS-4 and improved radiometric resolution from 7 bits to 10 bits for LISS-3 and LISS-4 and 10 bits to 12 bits for AWiFS. It also carries an additional announcement of opportunities payload, known as AIS (Automatic Identification System) from COMDEV, Canada, as an experimental payload for ship surveillance in Very High Frequency (VHF) band to derive position, speed and other information of ships.

Megha-Tropiques (Megha - cloud in Sanskrit and Tropiques - tropics in French) is an ISRO-CNES joint mission for the better understanding of the life cycle of convective systems

and their role in the associated energy moisture budget in the tropical regions. The satellite was launched by PSLV-C18 on October 12, 2011 into an 867 km orbit with 20° inclination. The satellite carried four scientific instruments, namely - (i) Microwave Analysis and Detection of Rain and Atmospheric Structures (MADRAS) (ii) SAPHIR, a six-channel humidity sounder (iii) SCARAB, a four-channel scanner for radiation budget measurement, and (iv) GPS-ROS, a GPS radio occultation system to provide vertical profiles of temperature and humidity of the Earth's atmosphere. All the payloads, except MADRAS, are performing satisfactorily and are providing useful scientific data for research and analysis. MADRAS sensor is not functioning now. However, the data provided by MADRAS for the first 16 months has been calibrated and archived for scientific studies and hosted through the Meteorological and Oceanographic Satellite Data Archival Centre (MOSDAC) portal.

Satellite with ARGOS and ALTIKA (SARAL) is a joint ISRO-CNES satellite mission to study the sea surface height. It was successfully launched into a Sun-synchronous orbit at an altitude of 785 km on February 25, 2013, onboard India's Polar Satellite Launch Vehicle, PSLV-C20. SARAL payloads are accommodated in the Indian Mini Satellite-2 bus. The Ka-band altimeter, ALTIKA, provided by CNES, operates at 35.75 GHz for ocean applications. SARAL ARGOS Data Collection System contributes to the development and operational implementation of the global ARGOS data collection system for a variety of data from ocean buoys and transmits the same to the ARGOS Ground Segment for subsequent processing and distribution.

Cartosat-2 Series Satellite: Four Cartosat-2 series satellites were launched on June 22, 2016, February 15, 2017, June 23, 2017 and January 12, 2018 aboard PSLV-C34, PSLV-C37, PSLV-C38 and PSLV-C40, respectively. These satellites are similar to the earlier Cartosat-2, 2A and 2B. The Cartosat-2 series satellites are placed in orbit in a phased manner. The imageries from Cartosat-2 series satellites are useful for cartographic applications, urban and rural applications, infrastructure planning, coastal land use and regulation, utility management like road network monitoring, water grids for distribution, creation of land use maps, precision study, change detection to bring out geographical and manmade features and various other Land Information System (LIS) and Geographical Information System (GIS) applications. The mission life of these satellites is 5 years each. These spacecraft are capable of along-track and across-track steering, nominally up to ± 45° providing spot images in continuous imaging mode.

SCATSAT-1: The satellite was launched on September 26, 2016 onboard PSLV-C35. It is a continuity mission of Oceansat-2 Scatterometer to provide wind vector data products for weather forecasting, cyclone detection and tracking services to the users. The satellite carries

2.1 Earth Observation, Meteorological Satellite System and Applications

Ku-band Scatterometer similar to the one flown onboard Oceansat-2. The spacecraft is built around a standard IMS-2 Bus, and the mass of the spacecraft is 360 kg. The spacecraft was placed in Sun Synchronous Orbit of 720 km altitude with an inclination of 98.27 deg by PSLV. The mission life of the satellite is 5 years. The Scatterometer data is being disseminated to the global user community for deriving the global wind velocity (magnitude and direction) over the ocean surface, which is used as an input for weather forecasting, monitoring of cyclones and their trajectory, and ocean state forecasting.

Resourcesat-2A: Resourcesat-2A was launched on December 07, 2016 onboard PSLV-C36. It is a follow on mission to Resourcesat-2 and intended to provide data continuity to the users. The configuration is similar to Resourcesat-2, having three-tier imaging capability, with a unique combination of payloads consisting of three solid-state cameras, namely, a high-resolution Linear Imaging Self Scanning Sensor – LISS-IV, a medium resolution Linear Imaging Self Scanning Sensor – LISS-III and an Advanced Wide Field Sensor (AWiFS). The spacecraft mass is around 1235 kg with a power generation capacity of 1250 W and a mission life of 5 years. The satellite was placed in Sun Synchronous Orbit of 817 km altitude with an inclination of 98.69 deg.

HysIS: Hyper Spectral Imaging Satellite, HysIS weighing 380 kg was successfully launched by PSLV-C43 on November 29, 2018 with a mission life of 5 years. This satellite employs Hyper Spectral Imager to take images in Visible and Near Infra-Red and Short wave Infra red bands. It provides global coverage on a repetitive basis to users and supplements the data from the existing multi spectral sensors. A wide range of applications in agriculture, forestry, geological environments, coastal zones and inland waters, etc., are derived from stellite.

EMISAT: EMISAT is a user-defined satellite jointly developed with the user. The spacecraft is built around the Augmented IMS – II Bus capable of generating 965 W and is planned with a mission life of 5 years. EMISAT was successfully launched onboard PSLV-C45 on April 1, 2019.

RISAT-2B: RISAT-2B was successfully realised and launched onboard PSLV-C46 on May 22, 2019. The primary objective of the mission is to provide X-band SAR Services with an average daily revisit capability over the areas of interest, providing the maximum number of spot images in a given orbit. The satellite was realised with new technologies to provide continuity of services to RISAT-2 in a fast track mode. The spacecraft was built around a new Hexagonal structure with a separate payload module with a mass of 620 kg generating 1.3 kW of power for a mission life of 5 years.

It carries an X=band SAR with a Payload Radial Rib Reflector 3.6 m mesh antenna for Spot, Strip and Mozaic imaging modes. The spacecraft was placed at an altitude of 555 km.

Cartosat-3: Cartosat-3 was successfully launched onboard PSLV-C47 on November 27, 2019. It is a third-generation agile, advanced satellite, having very high-resolution imaging, to obtain imageries with spatial resolutions of 0.28 m in Panchromatic, 1 m in 4 band multi spectral and intended for advanced Cartographic Applications with an operational life of 5 years. The spacecraft is built around a hexagonal structure and weighing around 1616 kg generating 1850 W of power. The satellite was placed at an altitude of 509 km.

RISAT-2B-R1: RISAT-2B-R1 is a synthetic-aperture radar (SAR) imaging satellite for reconnaissance built by ISRO. It is part of India's RISAT series of SAR imaging spacecraft and the fourth satellite in the series. RISAT-2BR1, a follow on mission to RISAT-2B, provides continuity in X-band SAR services. The configuration of RISAT-2B-R is similar to RISAT-2B. It was launched by PSLV-C48 into a 576 km Low earth orbit on December 11, 2019.

EOS-01: EOS-01 was successfully realized and launched onboard PSLV-C49 on Nov 07, 2020. The primary objective of the mission is to provide X-band SAR imaging services with an improved frequency of observation over the area of interest. The satellite has the capability to operate in the day, night, and all-weather conditions and provides imaging data for various applications related to land, water and environment, which is required for agriculture, forestry, water resource, flood inundation estimation, and disaster management. This is the third satellite in the constellation of three satellites to meet the user requirement. All three satellites in the constellation viz RISAT-2B, RISAT-2BR1 and EOS-01 are performing to specification and providing satisfactory services to the users.

PSLV-C49/EOS-1

2.1 Earth Observation, Meteorological Satellite System and Applications

2.1.3 Meteorological Satellites in Service

INSAT-3D, an advanced weather satellite, was launched on July 26, 2013, and positioned at the orbital slot of 82° East longitude in the geostationary orbit. It has added a new dimension to weather monitoring through its Atmospheric Sounding System, which provides vertical profiles of temperature (40 levels from the surface to about 70 km), humidity (21 levels from the surface to about 15 km) and integrated ozone from surface to the top of the atmosphere. Payloads onboard INSAT-3D are 6 Channel Imager, 19 Channel Sounder, Data Relay Transponder (DRT) and Satellite Aided Search and Rescue (SAS & R) Transponder.

INSAT-3DR was launched on September 08, 2016 aboard GSLV F05 launch vehicle and positioned at the orbital slot of 74° East longitude in the geostationary orbit. It is the repeat mission of INSAT-3D satellite with improved geolocation accuracy and enhanced band-to-band registration. The radiometric measurements have also been improved using Black Body calibration. It is also having payloads Data Relay Transponder (DRT) and Satellite Aided Search and Rescue (SAS & R) Transponder payloads.

2.1.4 Future Earth Observation and Meteorological Missions

India's future Earth Observation (EO) programme will ensure continuity of the thematic application series of satellites, namely, Resourcesat and RISAT (Land & Water), Cartosat (Cartography), Oceansat (Ocean & Atmosphere) and INSAT (Meteorology). The overall aim is to maintain the continuity of services and carry out enhancements in technological capabilities with respect to sensors and payloads in order to meet the operational applications. In this regard, several satellites have been planned to be launched in conversant with ISRO's vision document. A brief description of these future missions is given here under:

INS-2TD

INS-2 TD: The prime objective of the mission is to demonstrate the in-orbit performance of new technologies identified for second-generation

Nanosatellite. It also incorporates the redundancy for critical systems and hence enhances the overall satellite reliability. The main bus capabilities are also enhanced to cater to a variety of payloads in the subsequent Nanosatellite missions. INS-2 TD carries a Thermal Imaging Camera (TIC) and is expected to improve the applications using the land surface temperature, the surface temperature of large wetlands/lakes etc. The TIC payload has a ground sampling distance of 166 m and a swath of 64x48 km.

INS-2B: INS-2B carries a nano Multispectral (Nano-MX) Imaging Camera as prime payload. Nano-MX has a ground sampling distance of 29 m and a swath width of 116 km. This payload has potential applications in the area of agriculture, forestry & environment, water resources, snow and glaciers, and geology.

The prime objective of the mission is to build a nanosatellite using INS-2 bus to cater to the applications specific to Bhutan territory. It incorporates the redundancy for critical systems like onboard computers, telecommand and telemetry systems. The enhanced capability of the main bus accommodates a secondary payload being developed by the Dept. of Information Technology and Telecom/Bhutan along with a primary payload from ISRO.

EOS-04: EOS-04 is configured to ensure continuity of Synthetic Aperture Radar in C-Band, providing Microwave data to the user community for operational services. The satellite has the capability to operate in day, night and all weather conditions with a Mission life of 5 years and provides imaging data for various applications related to Land, Water and environment, which find useful inputs for Agriculture, Forestry and Water resources management.

EOS-04 satellite loading to LSSC

EOS-06: The prime objective of EOS-06 is to ensure the data continuity with improved payload specification of Ocean colour and wind vector data to sustain the operational applications. This satellite is expected to improve the applications by providing additional data such as Sea Surface Temperature (SST), with more number of bands in the Optical region and in the Infrared region for atmospheric corrections. EOS-06 satellite is envisaged to carry Scatterometer, 13 band Ocean

Oceansat-3: Scatterometer

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Color Monitor (OCM-3) with a spectral bandwidth of 10-20 nm and better SNR as well as sea surface temperature monitor (SSTM-1) for Sea Surface Temperature measurement. An ARGOS-4 payload of CNES will also fly on-board the satellite under international co-operation.

EOS-07: The primary objective of the mission is to provide imaging capability with systematic coverage over the area of interest in the Indian Ocean region and also generate spot images over the land region as and when needed.

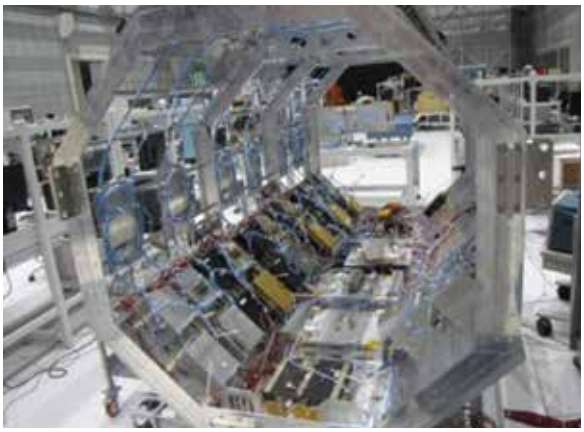
EOS-08: EOS-08 is an advanced agile satellite to obtain imageries for advanced cartographic applications with an operational life of 5 years. The satellite is built around a hexagonal structure.

Resourcesat-3/3A: The mission is envisaged to provide continuity of data services on an operational basis in the area of land and water resources management with improved spatial resolution, spectral resolution and better revisit frequency. It is planned to enhance remote sensing applications in the areas of agriculture, forestry, water resources monitoring, developmental planning at the regional and state level, environmental impact assessment, wasteland and wetland monitoring, land degradation, drought assessment, flood inundation, landslide inventory etc.

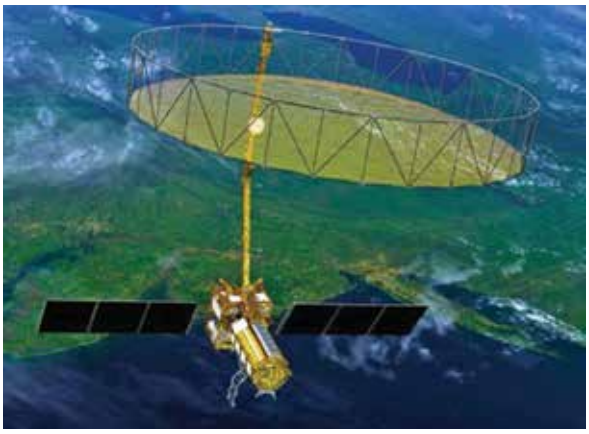
The satellite is built around I-1K bus capable of generating around 3200 W of power. The satellite carries advanced LISS-III, providing data continuity for LISS-III in VNIR & SWIR bands.

Resourcesat-3S/3SA: The satellite is planned to provide data services for earth resource monitoring with improved resolution and wide swath - stereo as well as multi-spectral capability on a single platform and enhance applications in the areas of land and water, large scale mapping, urban planning and infrastructure development, disaster impact assessment. The satellite is built around I-1K bus capable of generating around 3200 W of power. The satellite carries two panchromatic payloads providing a spatial resolution of approximately 1.25 m and a multispectral payload with a spatial resolution of approximately 2.5 m.

NISAR: This mission is jointly being developed by NASA and ISRO. The primary mission goals are global coverage of the earth's biomass, cryosphere for surface dynamics and coastal studies over a period of 3-5 years, systematic coverage of the global environment, Interferometry with precision orbit and pointing control.



NISAR Payload



NISAR

The mission is built around the I-3K bus and carries two payloads, namely L-band SAR and S-band SAR. NASA will deliver the L-band SAR payload and S-band SAR payload will be developed by SAC.

HRSAT: A constellation of small satellites with sub-meter resolution in PAN and a daily revisit capability has a great potential for civilian and commercial applications in large-scale mapping, agriculture, urban planning, rural development, infrastructure development, disaster management, etc. HRSAT carries advanced cameras such as Panchromatic Camera providing images with better than 1 m resolution, Multispectral Camera providing around 4 m resolution and LWIR camera with around 17 m resolution. HRSAT Mission is aimed at the design, development, and realisation of four identical integrated satellites.

INSAT-3DS: INSAT-3DS is a follow-on mission of INSAT-3D/3DR and will be used as a spare in case of contingency requirement. It is an advanced meteorological satellite configured with an improved Imaging System and Atmospheric Sounder. It carries two meteorological payloads namely 6 channel Imager and 19 channel Sounder. In addition to this, it also carries a Data Relay Transponder (DRT) and Satellite Aided Search and Rescue (SA&R) payload to provide continuity to INSAT Search and Rescue services. Considering the ground and on-orbit observations of INSAT-3D/3DR satellites, appropriate improvements/modifications have been incorporated into the INSAT-3DS configuration to optimize its performance. The satellite is built around the I–2K bus platform with a planned mission life of around 10 years. INSAT-3DS is designed for enhanced meteorological observations, monitoring of land and ocean surfaces, generating a vertical profile of the atmosphere in terms of temperature and humidity for weather forecasting and disaster warning.

2.1 Earth Observation, Meteorological Satellite System and Applications

2.1.5 Future Earth Observation and Meteorological Missions

Satellite Data Reception

IMGEOS: Integrated Multi-Mission Ground Segment for Earth Observation Satellites (IMGEOS) established at Shadnagar delivers emergency products in one hour and standard products in 24 hours. IMGEOS acquires data from various Indian Remote Sensing satellites and also from foreign satellites.

AGEOS: Antarctica Ground Station for Earth Observation Satellites (AGEOS) facility was established by ISRO during 2012-13 at Bharati (Research base of NCAOR), Antarctica. The data received from various Remote Sensing Satellites is transferred through a high-speed communication link to NRSC in near real-time.

SVALBARD and TROMSO Stations: Payload data dumped at these stations is being transferred through Network to IMGEOS, Shadnagar and Ancillary Data Processing is being carried out to generate Level-0 Products.

Establishment of New Antenna Terminals: NOVASAR Data reception and 7.3 m S/Ka-band antenna for Cartosat-3 data reception have been established at IMGEOS, Shadnagar.

7.3 m S/Ka-band antenna

Data Processing, Products, Archival and Web Applications: Data products were generated using the standard product and interactive product generation chain as well as from archives based on user demand. Geometric and Radiometric performance for ongoing optical remote sensing missions was periodically assessed through Data product quality evaluation of the respective missions.

Value Added Data products generation and dissemination: ISRO supported remote sensing application projects at the national level by generating value-added products viz, weekly NDVI, High resolution merged satellite data (of varying spatial resolutions) for Integrated Watershed Management Programme (IWMP), NABARD watersheds project, Space-based Information support for De-Centralised planning (SIS-DP), Atmospherically corrected National mosaics AWIFS images from Resourcesat series of satellites, etc. Besides, foreign high-resolution data sets based on user demand were also disseminated.

Bhuvan

Bhuvan (https://bhuvan.nrsc.gov.in) is a Geoportal platform of ISRO, with a host of wide-ranging services that cover visualisation of multi-date, multi-platform, multi-sensor satellite data, thematic map display, query and analysis, free data downloads and products, near real-time disaster services, Apps for crowd sourcing and diverse geospatial applications.

Bhuvan Geoportal served the nation to fight the COVID in the form of hosting the COVID vaccination centres in sync with COWIN-APIs and Tamil Nadu COVID Beds – live API with COVID bed details from Tamil Nadu Health Dept. . The portal also supported NITI Aayog with Agro-Forestry Site Suitability Index Map for pan India. Live Property Tax Mapping for Commissioner and Director of Municipal Administration (CDMA), Government of Telangana, is facilitated by Bhuvan.

Bhuvan Geoportal hosts 'Yuktdhara' which is a geospatial planning portal developed for Min of Panchayat Raj and is meant for facilitating gram-panchayat level planning of MGNREGA activities across India.

Bhoonidhi Vista

Bhoonidhi Vista is the data visualisation service of Bhoonidhi providing full resolution mosaicked data visualisation capability through WMS (Web Map Service) enabled for ResourceSat-2/2A, Sentinel-1 & 2 satellites. The users would be able to see the data on the web at varying zoom levels and various image processing steps are involved in preparing the data like format conversion, 8-bit conversion, Image Pyramid generation, Geo-referencing, FCC

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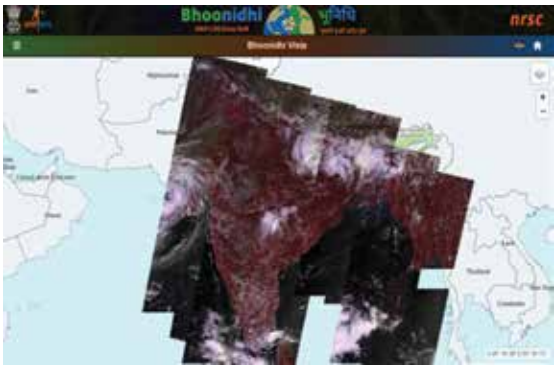
generation and alpha channel removal, Data publishing, as WMS, JP2 to geo-tiff conversion, Events Captured at Vista.

Satellite trace application named Upagrah is also integrated with Vista, which provides tracking of the live location of North American Aerospace Defense (NORAD) indexed satellites with satellite inertial coordinates, the speed with time.

Bhoonidhi Vista



Integration of Upagrah

Meteorological and Oceanographic Satellite Data Archival Centre (MOSDAC)

Following new applications were released on MOSDAC (mosdac.gov.in) during 2021.

- A web-based tool for Visualisation of Weather Forecast as charts on user requested location has been developed.
- Multi-Satellite Scatterometer Wind Visualisation and Analysis web application are designed to process operational wind products from open source international scatterometer missions (e.g., QuikSCAT, ASCAT, OceanSat-2 and Scatsat-1).
- Alerts, intensity and track forecast, inundation and surge forecast provided on newly designed SCORPIO website for the cyclones namely, Tauktae, Yaas, Gulab, Shaheen and Jawad.

Visualization of Earth Observation Data and Archival System (VEDAS)

- Near real-time daily Hydrological forecast is generated at 5x5 km spatial resolution. The model simulated fluxes such as river discharge, surface runoff, evapotranspiration and soil moisture are disseminated through the VEDAS web portal (vedas.sac.gov.in).
- Assessment of surface flooding over India from passive microwave radiometer was carried out and Near real-time Flood Index product based on Microwave Polarization Difference Index (MPDI) was operationalised on VEDAS web portal.

Aerial Services and Digital Mapping

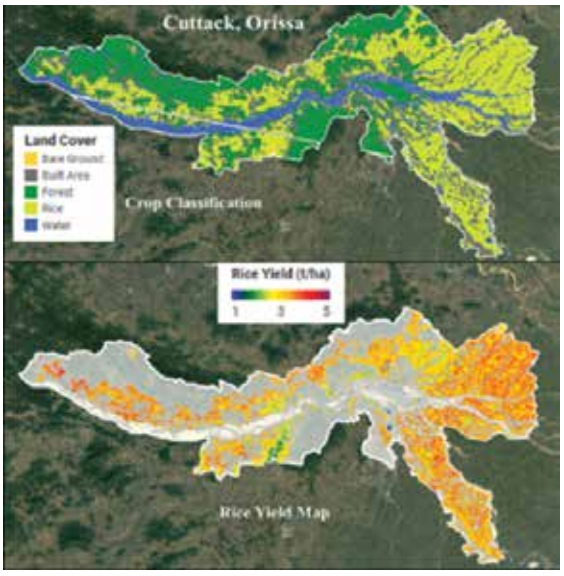
The Aerial Services and Digital Mapping area of NRSC is a unique facility with end-to-end capability and state-of-the-art infrastructure for Aerial Remote Sensing that comprises data acquisition of high-resolution data (up to 5cm GSD), ground survey, photogrammetric processing, generation of high-resolution digital elevation model with vertical accuracy of 20cm, fine contours of 0.4 m and large Scale Mapping up to 1:500 scale.

High-Resolution Digital Elevation Model (DEM) from Aerial/Terrestrial Platforms: NRSC has generated a high-resolution DEM with a vertical accuracy of 10 cm using airborne Large Format Digital Camera (LFDC) data with a ground sampling distance (GSD) of 5 cm for an area of 400 sq.km at Chitradurga and environs which is shown in the figure given below.

The precise Above Ground Level (AGL) Heights are computed using the above DEM, which is a key parameter for validating the altimeter readings of the Lander from sensors such as LASA (Laser Altimeter) and KaRa (Ka-Band Radio Altimeter). A ground GNSS base station is established and a DGPS survey is carried out to provide precise geodetic coordinates in WGS-84 datum for 12 monumented points in the Ullarthi Kaval test site for Chandrayaan-3 requirements.

Remote Sensing Applications

Agricultural Applications: A programme entitled SUFALAM (Space technology Utilisation for Food security AgricuLtural Assessment and Monitoring) has been executed for developing standard methodologies for new crop inventory, multi-scale crop yield models, value-added Agro-Met products for farmers' advisories and crop stress, solutions to crop insurance and agro-industries. Standard Operating Procedures (SOPs) of crop acreage using machine learning (ML) models have been developed for 8 crops out of 10 new crops. Several value-added Agro-Met products have been disseminated to more than 300 blocks covering six Agro-Met Field Units (AMFUs) under Gramin Krishi Mausam Seva (GKMS).



Web-based rice yield mapper

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Groundnut/Cotton discrimination algorithm: A methodology for groundnut/cotton discrimination based on time series of dual polarimetric SAR parameters from Sentinel-1 data is developed. This work differentiates itself from the traditional multi-temporal SAR backscatter analysis by incorporating polarimetric parameters such as the alpha angle (α) and the Polarimetric Radar Vegetation Index (PRVI) along with Random Forest classifier to aid discrimination. The methodology is demonstrated over the Junagadh district with an accuracy better than 92%.

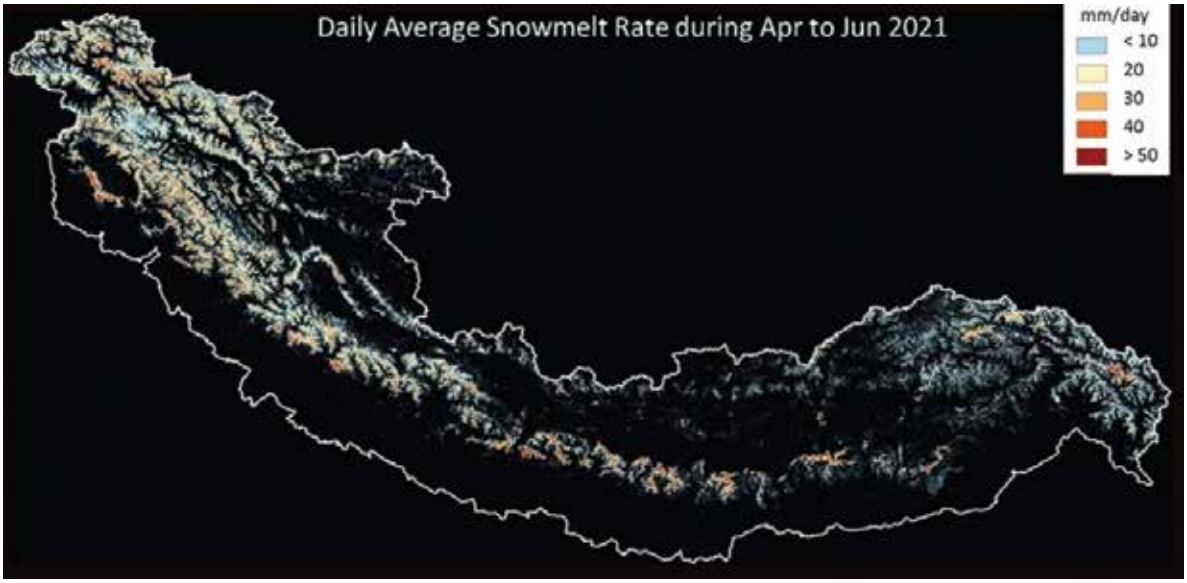
Desertification and Land Degradation: Land Degradation Status (LDS) mapping for the 2018-19 timeframe & change analysis with reference to 2011-13 timeframe were carried out for the entire country using IRS AWiFS satellite data at 1:50,000 scale. For the whole country, 126 map compositions were prepared and "Desertification and Land Degradation Atlas of India" was published in 2021.

Biodiversity Characterisation at the Community level in India: Developed methodology for spatial characterisation of vegetation communities using multi-sensor data and machine learning techniques. Finalized project manual for EO-based biodiversity monitoring at the community level. Prepared maps of dynamic habitat indices (DHI) using high temporal satellite data. Prepared database on Forest/land cover and forest fragmentation for 2008 and 2018 for 9 regional landscapes. Field inventory of 640 plots (9 sites) completed for 0.1 ha plots. Preparation of occurrence database on endemic species and threatened species is in progress.

Indian Bio-resource Information Network (IBIN): Indian Bioresource Information Network (IBIN) is a joint project of ISRO and the Dept. of Biotechnology (DBT). It is a single-window gateway dedicated to assimilating diverse data sources on India's bio-resources and biodiversities such as plants, animals, marine, microbial resources, and their spatial distribution. Species Distribution Modelling (SDM) as an open source-based machine learning modeling is designed and developed to predict the habitat suitability of plants and to estimate the role of important environmental variables in its existence, and Spatial Decision Support System (SDSS) model has been developed. It consists of over 44 thousand species of plants, animals, bacteria, fungi, protozoa etc.

Coastal dynamics Studies: The shoreline change atlas for the Indian coast was brought out in the form of 6 volumes of atlases, where the entire Indian shoreline is classified into accreting, eroding and stable shoreline. An Open source Quantitative Coastal Imaging Toolbox (QCIT) has been employed in video image analysis to generate Timex images, Geo-rectified images to identify rip current channels for a Video-based Monitoring System (VBMS).

Spatial snowmelt runoff Modelling in the Himalayan Region of Indian River Basins: A spatial snowmelt runoff model has been developed with the integration of multi-satellite data observations (snow cover, surface temperature, AOD, Ozone, Cloud cover, Solar radiation & Land cover) deriving energy balance. Daily snowmelt rates and 3-day (T+3 days) forecast were estimated during the snowmelt season of April to June of 2021 for the entire catchment area of Indian Himalayan river basins.



Daily average snowmelt rate during April to June, 2021

Glacial Lake Atlas: Inventory of Glacial lakes of size GT 0.25 ha (4,707 lakes) has been carried out for the Ganga river basin along with 22 attributes addressing hydrological, terrain and lake characteristics using IRS LISS4 MX data of 2016-17. The Glacial Lake Atlas of the Ganga River Basin was prepared and released in June 2021.

Sea ice Advisory for safer ship navigation during the Antarctic expedition: Sea ice advisory to National Centre of Polar and Oceanic Research (NCPOR) is incessantly made available to assess sea ice conditions for safer ship navigation for 39th Indian Scientific Expedition to Antarctica (ISEA) using optical and microwave data near to Bharati and Maitri stations. The feedback received from NCPOR and expedition voyage leader highlighted that the SAR-based inferred information of sea ice condition (type, concentration, deformation, leads etc.) helped in defining the route during the worst situation.

Delineation of surface coal fire and land subsidence in the Jharia coalfield: Coal fire is a serious problem in Jharia coal field, where high-ranking coals are gradually burnt due to

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these fires. Delineation of coal fire and mining-related land subsidence has been addressed. The thermal band of Landsat-8 (100 m resolution) has been used to demarcate the coal mine fire areas from nonfire areas. Further ALOS-PALSAR 2, L-band microwave data has been used to delineate the zone of probable land subsidence (using differential interferometry) due to mining.

Applications of Geospatial Technologies for monitoring of rural roads under Pradhan Mantri Gram Sadak Yojana (PMGSY): The high-resolution satellite imagery has been used to monitor rural roads constructed under Pradhan Mantri Gram Sadak Yojana (PMGSY). The rural road database has been prepared for 15 states of the country and its length has been compared with sanctioned road length as available through the Online Management, Monitoring and Accounting System (OMMAS) of MoRD. These GIS data on rural road contains the start, end and mid-point information along with connected habitation and Long Span bridges (LSB) for the completed roads. A Bhuvan-based dashboard is developed wherein different users based on authentication can access these databases for project monitoring purposes. This portal is further upgraded to capture the comments and revised start, end and mid points for the uploaded roads.

North Eastern Spatial Data Repository (NeSDR): NeSDR facilitates the users to visualize, retrieve, Geo-process and publish geospatial layers of interest generated for the region by the stakeholders. The NeSDR portal was released on 11th November 2020 with an objective to share the geospatial datasets among the User's Departments of the region to support their planning and developmental activities. The NeSDR is populated with more than 1044 datasets pertaining to land and water resources, infrastructure, disaster management supports etc. NeSDR also provides a platform for hosting Governance applications of Government Departments to empower planning and monitoring activities.

Swachh Bharath Mission: Optimisation and proposing feasible Sewage Treatment Plants' locations in small and Medium towns using Geospatial techniques has been carried out. Remote Sensing and GIS-based solution was provided for the identification of multiple feasible sites for locating Sewage Treatment Plants (STP) in 3,900 small and medium towns.

Ocean Colour and Biological Oceanographic Studies: The impact of two severe cyclones on ocean biological productivity, which occurred during May 2021 in the Arabian Sea and Bay of Bengal, was studied using multi-sensor data of ocean colour, Scatterometer, thermal infrared and altimeter. The derived and modelled ocean products were analysed before, during and after the cyclone period in both basins to study the effect of cyclone-induced increase in

chlorophyll concentration. In both the basins, an increase in chlorophyll concentration was observed along the cyclone track after the passage of the cyclone. However, the increase was more significant (>100%) in the coastal region and approximately 40% in the open ocean region of the Arabian Sea during Tauktae compared to an average increase of 30-40 % in the Bay of Bengal during the Yaas cyclone.

Compact Underwater Altimetry System Development: Compact Underwater altimetry system is designed and developed using a point sensor for measuring the water depth in the water bodies, up to 100 m, along with dissolved oxygen, temperature and position information. The system can be mounted on a remotely operated platform. The outputs expected from the system are Dissolved oxygen, Surface temperature and position apart from the Synchronized bathymetry.

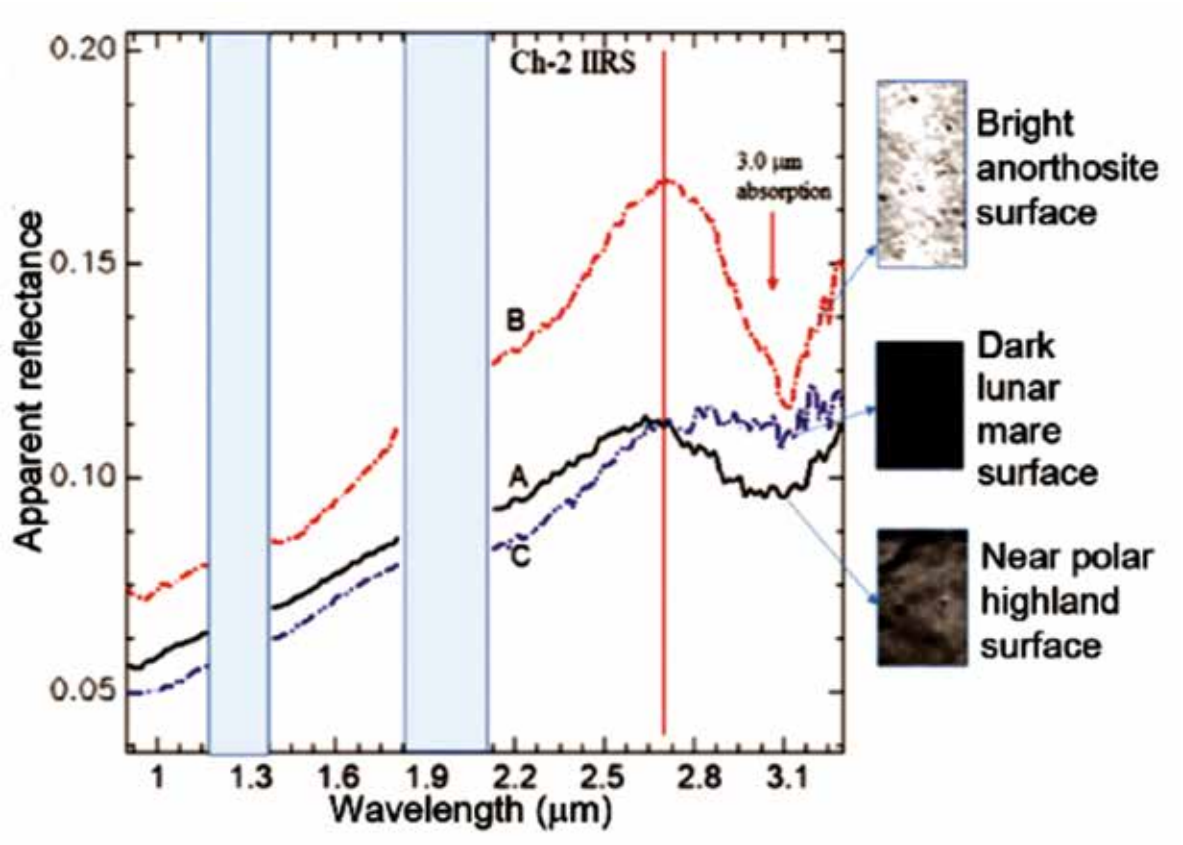
Development of Data Assimilative (Satellite and in-situ) Module - Technology Transfer to INCOIS, MoES: A Data Assimilation (DA) technique is developed and implemented into the operational wave model at INCOIS for assimilating near-real-time Significant Wave Height (SWH) observations from satellite altimeters and in situ buoys in the Indian Ocean. Assimilation of altimeter data improved the wave forecast in the northern Indian Ocean region up to about 15% in the initial 24 hr period.

Retrieval of rapid scan AMV from INSAT-3DR for cyclone tracking: A preliminary algorithm has been developed to retrieve atmospheric winds using rapid scan images of INSAT-3DR. The rapid scan atmospheric motion winds derived over the Indian Ocean region using infrared channel and water vapor channel of INSAT-3DR for Gulab cyclone. Frequent images of high-density winds in rapid-scan mode enable improved tracking of cloud motions. These high temporal winds are useful to the operational forecaster.

Detection of OH and H_2O on the Moon Surface: Reflectance data from Imaging Infrared Spectrometer (IIRS) on-board ISRO's Chandrayaan-2 mission were analyzed for detection

2.1 Earth Observation, Meteorological Satellite System and Applications

of hydration features on the lunar surface. IIRS instrument covers a spectral range from 0.8-5.0μm with a spatial resolution of about 80 m. The hydration feature in the spectral range of 2.8-35 μm (specifically at 3.0 μm) is due to absorption caused by the presence of OH and H_2O.



Significant lunar hydration feature varying with different surface composition

Disaster Management Support

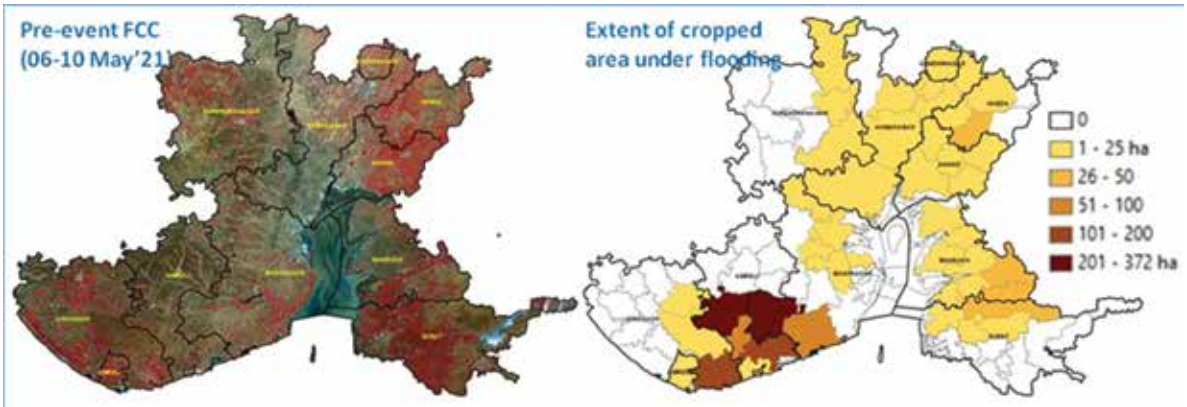
Floods & Cyclones 2021: Major flood events were monitored and mapped in near real-time mode using multi-sensor and multi-temporal satellite datasets in about 192 districts spread across 15 states (Andhra Pradesh, Assam, Bihar, Uttar Pradesh, Karnataka, Uttarakhand, Kerala, Odisha, Himachal Pradesh, Madhya Pradesh, Maharashtra, West Bengal, Gujarat, Tamil Nadu & Rajasthan) either by riverine floods or floods induced due to cyclone induced rainfall during 2021.

Chamoli flash flood in Uttarakhand had taken place due to massive land slide which was monitored continuously. Damage caused to the Tapovan project was assessed using high-

resolution satellite data. Further, a lake formed on Rishi Ganga was monitored continuously and a hydrological as well as hydro-dynamic study was done to assess the possible threat in case of a breach to the lake and the inputs were provided to MHA, NDMA, and Uttarakhand DMS organisations in near real-time.

Damage to Tapovan Project due to flash flood in Rishi Ganga River as viewed by Cartosat Satellite

Assessment of Tauktae cyclone effect on standing crop area in Gujarat: A fast-track study was carried out to estimate the damage to standing agricultural crops due to cyclone Tauktae that hit Gujarat in May 2021.



Taluks with maximum cropped area under inundation (> 100 ha)

SL.	DISTRICT	TALUK	AREA UNDER STANDING CROP (ha)	CROP AREA AFFECTED BY FLOODING (ha)
1	AMRELI	DHARI MAHAL	5644	372
2	BHAVNAGAR	KUNDLA	4717	212
3	AMRELI	RAJULA	3612	113
4	JUNAGADH	UNA	12084	111

Extent of crop area affected due to Tauktae cyclone

Standing crop area was estimated from pre-cyclone optical images of the study area from Sentinel-2. The cumulative flooded area layer of May 17-22 (from DSC) was used to estimate the affected crop area. Taluk-wise standing crop area and affected area statistics were generated.

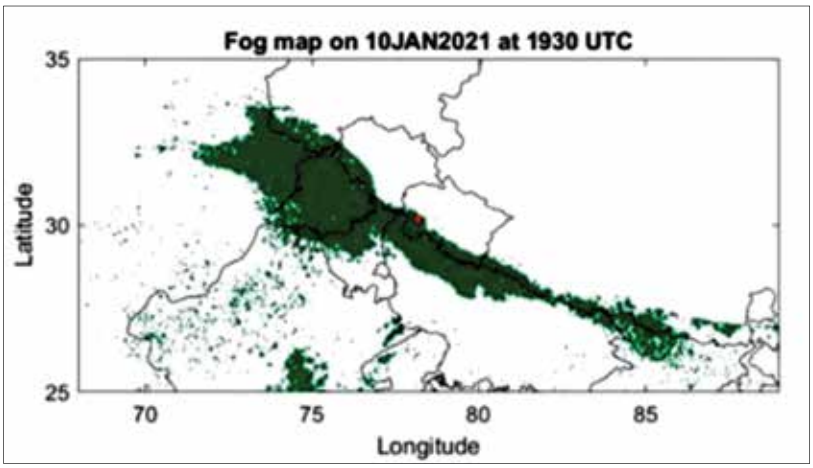
North Eastern Regional Node for Disaster Risk Reduction (NER-DRR): Established at NESAC in 2011, NER-DRR realised a comprehensive geo-spatial database, decision support tools and

2.1 Earth Observation, Meteorological Satellite System and Applications

actionable products and services for disaster risk reduction in the region. It disseminates products and services to the concerned National, State and District nodal agencies. Currently, under NER-DRR flood monitoring and early warning, Crop Damage Assessment and Monitoring, Landslide susceptibility mapping, Forest fire assessment, Severe Thunderstorm & Lightning Nowcasting are being carried out.

Flood Early Warning Systems (FLEWS): As part of NER-DRR, the flood Early Warning System (FLEWS) in Assam is currently an operational activity under funding from the Government of Assam. 29 Flood Alerts have been given for the Assam for the monsoon period of 2021. FLEWS is being extended to three more States (Arunachal Pradesh, Meghalaya and Tripura) and 13 flood alerts have been given during 2021 monsoon for these states. Post-flood satellite data were used to identify the embankment breaches due to the floods and 17 breach locations were identified in 9 districts of Assam.

Satellite-based study of fog: Fog is a cloud of small water droplets or ice crystals suspended in the air, influenced by water bodies close-by, wind conditions and topography. The widely used technique for nighttime fog retrieval is based on the brightness temperature difference (BTD) of TIR (10.8 µm) and MIR (3.9 µm) channels. The emissivity of fog in MIR channel is much less than emissivity in TIR channel due to similarity of fog droplets size with 3.9 µm wavelength. The BTD method is very versatile to the types of terrain and surface temperatures over which it can detect fog. Figure shows an example for fog maps generated for December 16, 2019 at 1800 UTC and 1815 UTC using INSAT-3D and INSAT-3DR imager, respectively. From the figure, the spread of the fog can be seen over Punjab, the northern part of Haryana, and the north-west of Uttar Pradesh.



Fog maps generated using INSAT-3D Imager data for Jan 10, 2021 1930 UTC

2.2 Communication Satellite Systems and Applications

2.2.1 Communication Satellites

The communication satellites have been contributing significantly to the socio-economic developmental and strategic activities in the country. At present, there are 17 satellites in operation. Of these, 3 are for strategic uses, 1 for international cooperation, 3 are new generation high throughput satellites (HTS) and the remaining 10 are for commercial and societal applications. The details of the operational satellites are briefed in the following sections.

2.2.2 Satellites in Service

GSAT-8

GSAT-8 is a 3000 kg class (I-3K) communication satellite launched in May 2011. It carries Ku-band commercial transponders as well as a two-channel GAGAN (GPS Aided GEO Augmented Navigation) payload operating in L1 and L5 bands.

GSAT-10

GSAT-10 launched on September 29, 2012; weighing 3400 kg at lift-off, carries payload in normal C-band, Extended C-band and Ku-band, and a GAGAN payload operating in L1 and L5 bands.

GSAT-14

GSAT–14 spacecraft provides Extended C-band and Ku-band communication transponder capacity. It also carries Ka-band Beacons. Designed with a mission life of around 12 years, it employs the standard I–2K bus. GSAT-14 was successfully launched on January 05, 2014 on-board GSLV-D5 Mission, the second development flight of GSLV with indigenous Cryogenic stage.

GSAT-16

GSAT-16 is a communication satellite configured around I-3K Extended bus with a lift-off mass of 3150 kg with a mission life of more than 12 years. The spacecraft's payload includes transponders in Ku-band, C-band and Extended-C band. The satellite was launched on December 07, 2014.

2.2 Communication Satellite System and Applications

GSAT-6

GSAT-6 Spacecraft is configured based on ISRO's I-2K Bus. This communication satellite was launched onboard GSLV-D6 on August 27, 2016. It provides communication through S-band payload with five spot beams covering the whole India for user links and C-band beam for hub links. It carries a 6 m diameter S-band unfurlable antenna.

GSAT-15

GSAT-15 is a communication satellite configured around I-3K bus and it is designed for a mission life of more than 12 years. The payload includes Ku-Band transponders and a two-channel GAGAN payload. The satellite was launched in November 11, 2015.

GSAT-18

GSAT-18 is a communication satellite configured around I-3K extended bus and it carries Ku, Normal C and Extended C-band transponders. It is designed for a mission life of more than 15 years. The satellite was launched on October 06, 2016.

South Asia Satellite

GSAT-9 or South Asia Satellite is realised for the benefit of people of South Asian countries Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal and Sri Lanka. The satellite carrying Ku-band transponders was launched onboard GSLV-F09 on May 05, 2017, from Sriharikota. It is configured around the ISRO's standard I-2K bus. The satellite is designed for a mission life of 12 years.

GSAT-19

GSAT-19 satellite with a lift-off mass of 3136 kg is a communication satellite configured around ISRO's standard I-3K Bus. It carries Ka/Ku-band high throughput communication transponders. The satellite provides 8 user beams in the Ku-band and 2 gateway beams in Ka-band. It was launched onboard the first developmental flight GSLV Mk-III D1 on June 05, 2017, from Sriharikota.

GSAT-17

GSAT-17 is a communication satellite launched on June 29, 2017, with a lift-off mass of 3477 kg. It carries payloads in Normal C-band, Extended C-band and Sband to provide various communication services. It also carries a payload for data relay transponder and satellite-based search and rescue services. The satellite also has transponders in Extended C-band that provide connectivity to Antarctica. The designed in-orbit operational life of GSAT-17 is about 15 years.

GSAT-29

GSAT-29 Spacecraft is a communication satellite configured with ISRO's enhanced I-3K Bus launched an on-board second developmental flight of GSLV Mk-III D2 on November 14, 2018, with lift-off mass of around 3500 kg. It is configured with payloads to provide spot beams in Ku and Ka-band covering North East and Jammu and Kashmir regions. The satellite also carried Q/V-band payload, optical communication payload and high-resolution geo camera as technology demonstrators. The designed in-orbit operational life of GSAT-29 is about 10 years.

GSAT-11

GSAT-11 is a communication satellite launched on December 5, 2018, onboard Ariane-5 VA-246 with a lift-off mass of 5854 kg. GSAT-11 is a multi-beam high throughput communication spacecraft operating in Ka- and Ku- bands employing a new bus. It provides 32 user beams in Ku-band and 8 gateway beams in Ka-band. The payload includes Ka x Ku band forward link transponders and Ku x Ka band return link transponders. The designed in-orbit operational life of GSAT-11 is about 15 years.

GSAT-31

GSAT-31 was successfully launched on February 06, 2019, from Kourou with the lift of mass of about 2536 kg. GSAT-31 is configured on ISRO's enhanced I-2K Bus. It is a communication spacecraft carrying Ku-band transponders. The satellite provides Indian mainland, island and ocean coverage.

GSAT-30

GSAT-30 was successfully launched on January 17, 2020, from Kourou with the lift of mass of about 3357 kg. GSAT-30 is configured on ISRO's enhanced I-3K Bus. It is a communication spacecraft carrying Ku-band transponders and C-Band Transponders with 36 MHz bandwidth. The satellite provides Indian mainland and islands coverage in Ku-band and wide coverage over encompassing India, Gulf countries, a large number of Asian countries and Australia in C-band.

CMS-01

CMS-01 is a communication satellite envisaged for providing services in Extended-C band of the frequency spectrum. The Extended-C band coverage includes the Indian mainland, Andaman-Nicobar and Lakshadweep Islands. The satellite was successfully launched onboard PSLV-C50 on December 12, 2020.

2.2 Communication Satellite System and Applications

2.2.3 Satellites under Development

GSAT-20

GSAT-20 Spacecraft is configured based on ISRO's standard I-3K Bus. It is a communication spacecraft to be launched onboard GSLV Mk-III. It has Ka x Ka high throughput payload. Presently, the satellite subsystems are under realisation.

GSAT-22, 23 & 24

The three communication satellites GSAT-22, 23 and 24 has been configured with ISRO's standard I-3K Bus. These satellites will carry Ku-band transponders capable of supporting DTH services.

GSAT-24: Integrated Payload

2.2.4 Satellite Communication Applications

A fleet of 17communication satellites is operating over India with communication transponders in C-band, Extended C-band, Ku-band, Ka/Ku-band and S-band. These satellites together provide 292.5 operational bent-pipe transponders and 25 Gbps high throughput satellite (HTS) capacity. These satellites support the services like television broadcasting, DTH television, telecommunication, VSATs, radio networking and societal applications. The prominent users of the transponders are Government & special users, Prasar Bharati, DTH and TV operators, Public sector units (BSNL, ONGC, AAI, ECIL etc.), private VSAT operators, banking and financial institutions, etc.

DOS has continued the support for societal programmes like tele-medicine, tele-education and Disaster Management Support (DMS) Programmes which are solely national development-oriented with an aim to address specific requirements at different strata of the society.

In order to meet additional transponder requirements from various user sectors, about 65 transponders in Ku-band and HTS capacity of 1.83 GHz are leased from international satellite operators on a back-to-back arrangement with users and satellite operators. In addition, about 40 transponders in C-band are directly leased by the broadcasters for TV uplinking. Thus, satellite communication is playing a major role in the socio-economic development of the country.

Television

GSAT satellites have been a major catalyst for the expansion of television coverage of Doordarshan. DOS/ISRO has made available the required transponders through GSAT satellites and through a leased capacity to cater to the needs of the broadcasting sector.

Doordarshan is presently operating 36 satellite channels and has a vast network of studios and terrestrial transmitters (including 23 DTTs) of varying power installed throughout the length and breadth of the country.

DD has 41 C-Band Earth Stations (ES) for program contribution and distribution of DD Channels and one C-Band DTH ES for providing DTH service to Andaman and Nicobar Islands, where Ku-Band DTH footprints are not available. Out of 41 C-band earth stations, Doordarshan has upgraded nine C-band earth stations at DDK Delhi, CPC Delhi, Bengaluru, Hyderabad, Patna, Dehradun, Srinagar, Raipur and Ranchi, which are equipped with MPEG-2/4 compliant SD/HD

2.2 Communication Satellite System and Applications

compression chain and spectrum efficient DVB-S/S2 compliant RF chain equipment. These earth stations are capable of uplinking HD/SDTV channels. Doordarshan is using a total of 18.36 Transponders (12.03 C-band and 6.33 Ku-band) of 36 MHz each on GSAT satellites.

In addition, Doordarshan provides its free-to-air DTH service "DD Free Dish" with the primary objective of providing TV coverage to the uncovered areas. DTH signals can be received anywhere in the country by installing small user terminals. For A&N Islands, DTH service is provided in C-band with a bouquet of 10 channels. Presently, DD Free Dish broadcasts 116 TV Channels (including one HD Channel) and 48 Radio Channels. Doordarshan has planned to enhance its DD Free Dish platform to 250 Channels.

Digital Satellite News Gathering (DSNG) and Events Broadcasting

Doordarshan has inducted 9 C-band DSNG vans equipped with MPEG-4 compliant SD/HD compression chain and spectrum efficient DVB-S/S2 compliant digital modulators. These new DSNG vans are being operated by sharing the existing frequency of C-band DSNGs deployed in DD network. Presently, Doordarshan has 25 C-band and 8 Ku-band Digital Outdoor-Broadcast Digital Satellite News Gathering terminals operating through GSAT satellites.

Satellite Radio Networking

The satellite-based connectivity for radio networking covers 90 Digital Channels (Through Captive Earth Station - 80 Channels and DSNG – 10 Channels) for National, Regional and Vividh Bharati Networking through GSAT-10 (For Coverage Over Indian Geographic Main Land) & GSAT-18 (For Coverage Over Andaman & Nicobar and Lakshadweep Islands). The radio network is supported using 44 Captive Earth Station & DSNG and 509Down Link Radio Network Terminals (RNTs). AIR is also Broadcasting 48 Radio Channels on DTH Platform of Doordarshan 'DD Free Dish'.

Telecommunications

GSAT satellites have been supporting telecommunication applications for providing voice, data and broadband services. Satellite links are the primary means of connectivity to remote, far-flung and difficult to access regions of the country and play the role of backup links for a large number of services on terrestrial connectivity. Satcom links have a major role in banking sectors linking the ATMs with banks.

1590 Satellite Earth Stations of different sizes are operating in satellite networks of BSNL, Government users, Closed user groups, commercial users and broadcasters and are being

utilised for telecommunications/broadcasting applications. As per provisional estimates, about 2.84 Lakh VSATs are being used in star/mesh connectivity of various sizes and capabilities.

Satellite-based captive networks are operational using VSAT systems for establishments like NTPC, ONGC, IOCL, ERNET, Indian Railway, Karnataka Power Transmission Corporation Ltd., etc., apart from private enterprises. In addition, GSAT satellites cater to captive government networks of various ministries.

Tele-medicine

Satellite Communication based Tele-medicine is one of the unique applications of space technology that is being utilised for the benefit of society. Tele-medicine technology utilises an Information & Communications Technology (ICT) based system consisting of customised Tele-medicine software integrated with computer hardware and medical diagnostic instruments connected to the commercial Very Small Aperture Terminal (VSAT). Tele-medicine enables the patient to 'see & interact' with the doctor live through video links.

ISRO's Tele-medicine programme has been connecting various remote & rural medical colleges & hospitals and mobile units to major specialty hospitals in cities and towns using satellite communication. At present, around 210 Tele-medicine nodes are operational, which have been upgraded with new in-house developed interactive software "Daksh". Out of these, 20 tele-medicine nodes are located at very high altitudes in Siachen.

DECU is the nodal unit of ISRO implementing the tele-medicine Network. Several nodes for Defence & Paramilitary forces have been established in remote, inaccessible and high-altitude areas such as Jammu & Kashmir, Leh, Ladakh, including the Siachen glacier. Two more nodes, a doctor node at Military Hospital, Dehradun and a patient node at Military Hospital, Dalhousie were established as per request from Integrated Defence Staff (IDS)-Medical. Three nodes for Indo Tibetan Border Police Force (ITBPF) are being installed & commissioned. In addition to this, discussions were held with several users such as Border Roads Organisation (BRO), Ladakh, Lakshadweep, etc., for their requirement of new TM nodes.

Continuing Medical Education (CME) programmes are conducted from DECU Studio or from remote user-ends, especially the Defence nodes, in which medical experts/doctors share their knowledge and experiences and interact with the connected remote hospitals. Users have been enabled to conduct CMEs from their respective TM centres. Several CMEs have been conducted by users such as Air Force Hospital on topics such as "COVID-19 Vaccines". DECU Studio has been utilised for conducting five CMEs following all COVID-19 precautionary

2.2 Communication Satellite System and Applications

guidelines on topics such as "Preparation for Third Wave of COVID", "Myths and Facts about COVID-19 Vaccine", "COVID-19 Updates, COVID-19 Complications and Management", etc.

Tele-education

Tele-education programme has manifold objectives such as supplementing the curriculum-based teaching, imparting effective teacher training and providing access to quality resource persons and new technologies, thus, taking education to every nook and corner of India. ISRO provides connectivity to schools, colleges and higher levels of education and also supports non-formal education, including developmental communication. The tele-education networks implemented under this programme comprise of two types of terminals, namely, Satellite Interactive Terminals (SITs) and Receive Only Terminals (ROTs). At present, around 44 networks are operational, with 24 Hubs connecting about 1400 SITs and 33000 ROTs. The operations and maintenance are taken care of by the respective user agencies under State/ Central Government Departments. Support was provided to NE-SAC/ ISRO for the operations of North Eastern Region Tele-education networks. For continuity of TE services in J&K, Hub operations and Facility management contract of TE Hub at Jammu was extended. Technical consultancy services on varied requirements were provided to several user agencies such as Punjab, Kerala, Uttarakhand, etc. on a need basis.

Social Research & Evaluation

Various social science and communication research studies are carried out for tele-medicine, Tele-education, Communication Requirements and other applications to understand the societal needs and requirements for development. For tele-education, Social Research & Evaluation mainly focuses on feedback and utilisation studies of various TE networks based on field visits and monitoring of live programmes. Similarly, studies for the requirement of tele-medicine services & health needs are also carried out in various parts of the country.

Several studies were completed, such as "A Feedback Study on Usage of Solar Application," "Perception and Barriers towards Online Classes among KV-SAC Students duringCOVID-19 Pandemic Lockdown", Impact of MOSDAC Web Portal on Research Activities of Users, Exploring Usefulness of North Eastern District Resources Plan (NEDRP) Geo portal in North Eastern Region (NER),etc.

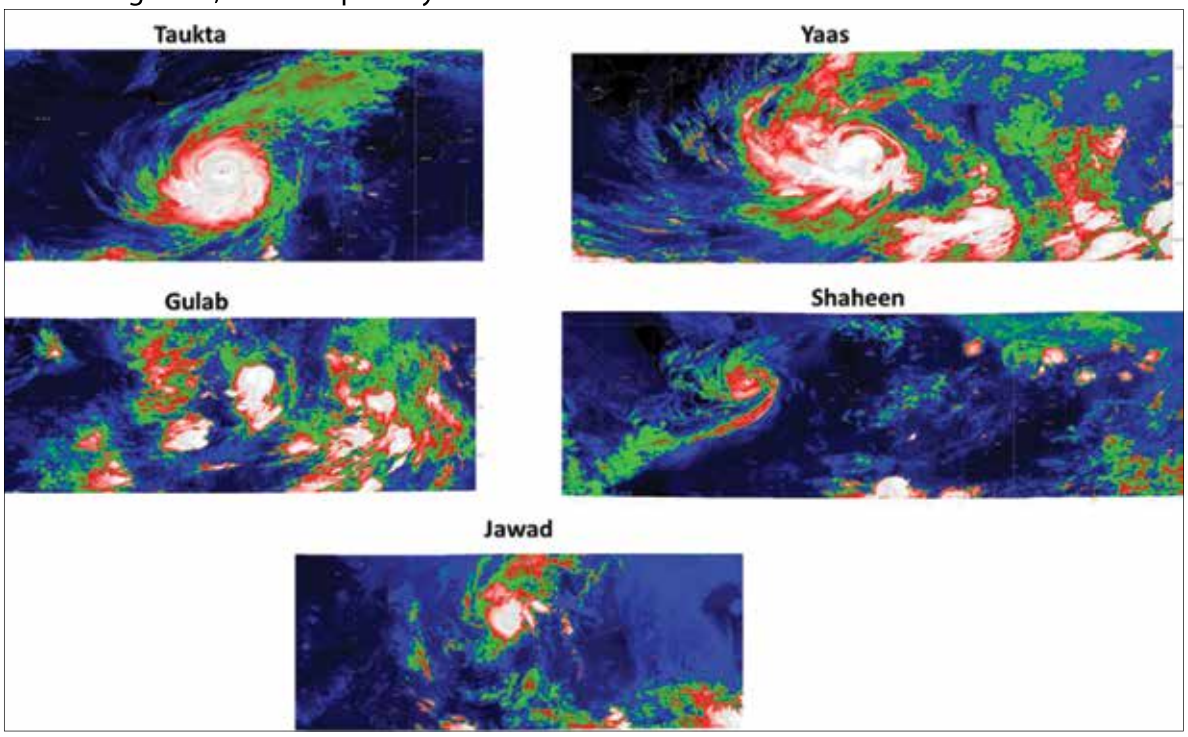
Various studies are ongoing such as A Feedback Study on Karnataka Tele-Education Network, Impact of RESPOND programme in SAC: A Study on Academic Institutes in Western Region of India, Usefulness of NavIC and GPS based Vehicle Location Tracking System (VLTS),etc.

By continuing expansion of Satcom application programmes such as tele-medicine, tele-education, social research and developmental education, DECU carries the benefits of space technology directly to the common person and strongly contributes to national development.

Satellite Meteorology

Satellites provide the essential inputs for meteorological applications. INSAT-3D and INSAT-3DR (Imager, Sounder, DRT) satellites carrying meteorological payloads are supporting weather forecasting services. The data received from the satellites is processed and disseminated by INSAT Meteorological Data Processing System (IMDPS) at India Meteorological Department (IMD). The system is capable of receiving and processing the data of both INSAT-3D and INSAT-3DR. The performance of the system during the current year has been maintained to the level of 99% operation efficiency (24x365 bases).

The Imager payload of INSAT-3D and INSAT-3DR is being used in the staggered mode so that a 15 minutes temporal resolution is achieved. During extreme weather events, the INSAT 3DR imager is used for RAPID scanning. Advanced Dvorak Technique (ADT) software customized for INSAT-3D was implemented to determine the intensity of Tropical Cyclones. Rapid scan has been conducted during major cyclonic events like Tauktae, Yaas, Gulab, Shaheen, and Jawad, etc. During 2021, these tropical cyclones were monitored with INSAT 3D and 3DR.



INSAT-3DR Imager rapid scan during cyclonic storms

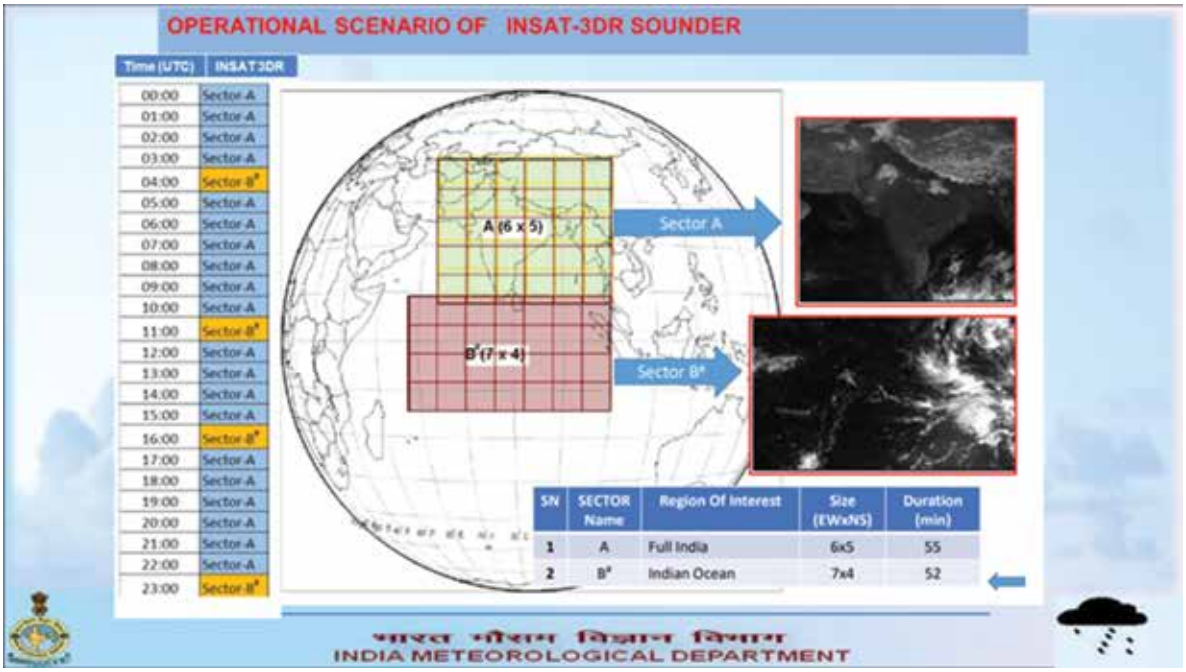
2.2 Communication Satellite System and Applications

The sounder payload of INSAT-3DR is operated in such a way that INDIAN land region sector data is covered up twenty times and the Indian Ocean region data is covered up four times a day.

Satellite technology is of great use in meteorology and plays a very significant role in the improvement of weather forecasting and dissemination. In fact, the improvement in weather forecasting is mainly attributed to the increasing use of satellite data.

Satellite Aided Search and Rescue (SAS&R)

India is a member of the international COSPAS-SARSAT programme for providing distress



Scan strategy of INSAT-3DR sounder

alert and position location service under the Search & Rescue (SAR) programme through the satellites in Geostationary Earth Orbit (GEO) and Low Earth Orbit(LEO). Under this programme, India has established two Local User Terminals (LUTs) for LEOs at Lucknow and Bengaluru, whereas the LUT for GEO is established at Bengaluru. The Indian Mission Control Centre (INMCC) is located at ISTRAC, Bengaluru.

The operations of INMCC/LUT are funded by the participating agencies, namely, the Indian Coast Guard, Airports Authority of India, Directorate General of Shipping and Defence Services and the system has been operational for the past 30 years.

INSAT-3D (82Deg East), INSAT-3DR (74Deg East) and GSAT-17 (93.5 Deg East) carry Search and Rescue payloads operating at 406 MHz . INSAT-3DR & GSAT-17 are in operation to pick up and relay the distress signals originating from the distress beacons of maritime, aviation and other users in the Indian subcontinent. INMCC also extends the SAR services to Bangladesh, Bhutan, Maldives, Nepal, Seychelles, Sri Lanka and Tanzania. In the current year, a standby downlink chain for GEOLUT is established and made operational with 1+1 configuration.

The distress alert messages concerning the Indian service area, detected at INMCC, are passed on to the Maritime Rescue Coordination Centres (MRCCs) of Indian Coast Guard (Mumbai, Chennai, Port Blair), and the Rescue Coordination Centres (RCCs) of AAI (Chennai, New Delhi, Kolkata, Mumbai). The search and rescue activities are carried out by Coast Guard, Navy, AAI, NDRF and Air Force. INMCC is linked to the RCCs, MRCCs, SPOCs (Search and Rescue Points of Contact) and other International MCCs (Mission Control Centres) through Aeronautical Fixed Telecommunication Network (AFTN) and File Transfer Protocol (FTP). The Indian LUTs and MCC provide round-the-clock service to all ships, aircraft and other users. It also maintains the database of all 406 MHz registered beacons carried by Indian ships, aircraft and other users.

GEOLUT 3.7 m antenna

Presently INMCC is capable of receiving alerts from LEOLUT and GEOLUT (LG-MCC). Medium Earth Orbiting Local User Terminal (MEOLUT) is established during the year and its evaluation is in progress.

2.2 Communication Satellite System and Applications

From January to December 2021, INMCC provided search and rescue support to 13distress incidents in the Indian service area and contributed to saving 36 human lives. During this period, about 1838 new radio beacons were added in the Indian database. Till date, there are1018 registered users and the total number of registered beacons is 18012.

22nd and 23rd Biannual beacon exercises were carried out involving ICG, Navy, DGCA, Indian Air Force and DG (shipping)/SCI from 28 to 30 April & 25 to 27 August 2021, respectively. Seminars and Workshops on SAR-related activities and operations were conducted for AAI, ICG and Defence and other users.

Distress Alert Terminal

ISRO had developed Distress Alert Transmitter (DAT) for fishermen to support emergency message reporting for maritime search and rescue operations. ISRO has upgraded the heritage DAT by interfacing with the NavIC messaging receiver to provide acknowledgment of emergency messages together with information like potential fishing zones and emergency broadcast messages from control stations. This makes the SAR efforts more effective & user-friendly, combining both Satcom & satnav features. In coordination with SAC, INMCC established DAT-SG (Second Generation) hub at ISTRAC. DAT-SG Hub includes a DAT user registration database service for Indian fisherman communities. System T & E and commissioning will be completed in the near future.

South Asia Satellite

South Asia Satellite (SAS) was launched on May 5, 2017, to provide satellite connectivity to neighbouring nations. This satellite is carrying 12 Ku-band transponders with coverage over Afghanistan, Bangladesh, Bhutan, India, The Maldives, Nepal and Sri Lanka.

A SatCom network has been established using one transponder in Bhutan for utilisation of SAS and operational since January 2019. The network is being used for unlinking 2 TV channels and 4 radio channels, connecting the Disaster Management Centres, Internet connectivity and backup for critical telecom links. Additional 20 MHz capacity is provided to them and the augmentation of ground systems is in progress. Bangladesh has started the utilisation of SAS with 10 terminals to connect schools at remote locations for internet and video conferencing from Hub support from New Delhi. Further, Bangladesh has established a dedicated network with a hub in Dhaka to connect about 150 terminals, using one transponder on SAS. The network is established by them. Maldives has established a network with 35 user terminals using one transponder with their own funding. The hub support was extended from the common Hub at DES, New Delhi. Sri Lanka is planning to establish Satcom network for

Sri Lanka Police through M/s. Bharat Electronics Limited, a year back. The proposal consisted of a Satcom network with a central hub and three types of user terminals to be deployed in Sri Lanka. A utilisation plan from Afghanistan is awaited.

Mobile Satellite Services (MSS)

Mobile Satellite Services encompass a comprehensive SATCOM network for communication using handheld and portable devices. Through this network and infrastructure, ISRO supports various communication applications for different user groups, namely Indian Railways, Ministry of Home Affairs and other special user groups. 6.3 m and 11.5 m C-band Earth stations at Ahmedabad & New Delhi with necessary baseband sub-systems have been established to provide uninterrupted services & demonstration.

Using MSS service, an indigenous solution has been developed and implemented for tracking the Trains in real-time, namely "Real-time Train Information System (RTIS)". This would enhance the safety and operations of the Train services. So far, 2700 trains are provided with tracking the position of locomotives which help in the generation of events like station Approach/ Arrival/Departure/Run through/Unscheduled Stoppage. Centre for Railway Information System (CRIS), a unit of Indian Railways, is the nodal agency for implementing the RTIS.

ISRO has carried out the development of SATCOM terminals for tracking of sub-24 m fishing vessels that go into the deep sea for several days. The system provides for both the safety of the fishermen as well monitoring their movements security reasons. Proof of Concept of this system with the development and installation of 500 Terminal in Tamil Nadu, Puducherry and Gujarat has been completed successfully. Further, Tamil Nadu has undertaken a rollout of this solution for 5,000 fishing vessels.

High Throughput Satellites

The satellite industry is gearing up to use High Throughput Satellites (HTS) across the world. India being an important user of satellite broadband applications, ISRO has launched HTS satellites GSAT-19, GSAT-11 & GSAT 29. These bigger and more powerful satellites are providing multiple spot-beam coverages in Ku &Ka bands. The throughput derived is several-order higher compared to traditional satellites. The throughput demand will be further augmented by the Ka x Ka HTS satellite in future. The capacity accruing will be used to cater to BharatNet and other VSAT-based applications.

Installation and commissioning of HTS ground stations of GSAT-11, GSAT-19 & GSAT-29 have been completed. BBNL has installed its full capacity baseband and providing services to more

2.2 Communication Satellite System and Applications

than 5000 user terminals across various user beams through GSAT-11 and GSAT-19. These terminals are mainly installed at Gram Panchayats (GPs) and various Government offices. BSNL has also installed its full capacity baseband and provided services to Lakshadweep and Andaman & Nicobar Islands for telecom services and backhaul connectivity.

2.3 Navigation Systems

ISRO is making continuous efforts to enable civilian sectors like land transportation, aviation, maritime, mapping, surveying, geodesy, timing, telecommunications, etc., to utilize the services offered by NavIC.

Major developments in this regard during 2021 have been:

1. NavIC in Mobiles:

To enable the use of NavIC in mobile phones, the efforts are being channelized with the following stakeholders.

a. Mobile Chip Manufacturers:

Major mobile chipset manufacturers have released mobile processors which are NavIC enabled.

b. Mobile Phone Manufacturers (OEMs):

Using these processors, mobile handsets with NavIC capability have been released by mobile OEMs. There are about 30 mobile handsets in India with NavIC capability.

2. NavIC in low power GNSS chips:

Newer applications like wearable devices, personal trackers, IoT devices, etc., require small form factors low-power GNSS chips. These are generally catered to by single frequency (L1) modules. In order to proliferate NavIC in this growing sector, all subsequent NavIC satellites will have civilian signals in L1-band in addition to legacy signals in L5 and S-bands. ISRO is interacting with GNSS chip manufacturing companies to accelerate the adoption of NavIC L1-signal into low-power GNSS chips.

3. NavIC Messaging Service:

a. NavIC Messaging Receiver:

Indian National Centre for Ocean Information System (INCOIS) effectively uses the NavIC messaging service to broadcast alert messages such as cyclones, high waves etc. and provide information on the Potential Fishing Zone (PFZ) for the fishermen venturing into the deep sea. This system is functional.

ISRO has become part of an initiative by the National Disaster Management Agency (NDMA) to evolve a Common Alert Protocol (CAP) for major natural disasters like landslides, earthquakes, floods, heavy rains, avalanches, etc. NavIC Messaging System has been one of the means of disseminating the alert messages and has been short-listed

2.3 Navigation Systems

for phase-1 implementation. ISRO has provided technical support to the implementing agency C-DOT in this regard and the development is as per schedule.

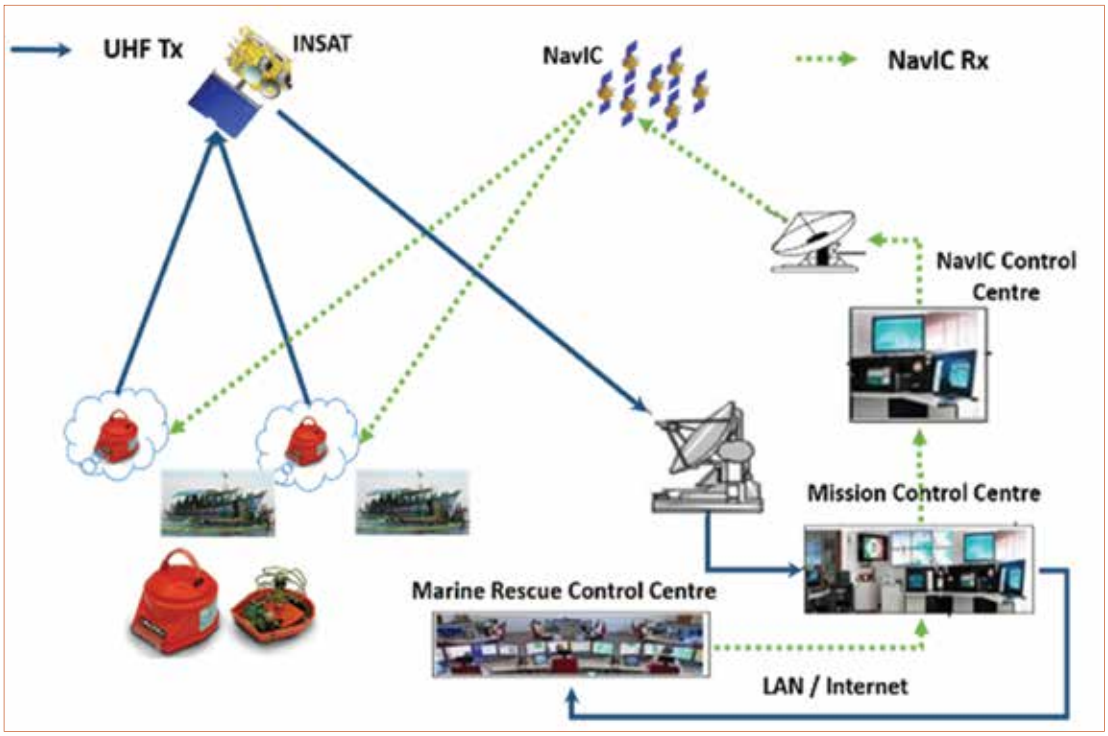
ISRO carried out a discussion with Galileo and QZSS to work out a standard format for broadcasting emergency warning messages among the three GNSS.

b. Second Generation Distress Alert Transmitter (SG-DAT):

ISRO developed Second Generation Distress Alert Transmitter (SG-DAT) by integrating the features of NavIC Messaging Receiver (NMR) and Distress Alert Transmitter (DAT). In this system, fishermen can send a distress alert through the regular DAT link to the rescue centre and the acknowledgment for the reception of distress signal and impending rescue attempt will be sent through the NavIC messaging service. The hub has been established at ISTRAC along with the existing COSPARSARSAT ground system. The T&E of the ground system is nearing completion.

SG-DAT terminal prototype development is completed and technology has been transferred to six industries through NSIL for commercial deployment.

The system will be ready for deployment in February-March 2022.



4. NavIC in Aadhaar Enrolment Centres

The unique Identification Authority of India (UIDAI) is currently using GPS-based receivers to capture the location of the enrolment center on a periodic basis. UIDAI approached ISRO seeking technical guidance for integrating NavIC into the receivers. In April 2021, ISRO provided NavIC enabled GNSS receivers for proof-of-concept demonstration and gave technical assistance for software integration, maintaining backward compatibility. UIDAI has reported that proof-of-concept testing is successful. Based on a subsequent request from UIDAI, ISRO is in the process of providing a few NavIC enabled GNSS receivers for field testing.

5. NavIC based Timing applications:

ISRO and NPL are assisting the Dept. of Consumer Affairs to establish one primary timescale at Bengaluru and five secondary timescales at Ahmedabad, Bengaluru, Bhubaneswar, Faridabad and Guwahati. These timescales will be integrated and operated with ISRO's in-house timescale software. The system architecture has been finalised and equipment specifications have been cleared for procurement. The procurement process is initiated. These timescales will provide accurate IST dissemination across India and will contribute to enhancing cyber security resilience.

6. NavIC based Scientific Applications

a. Continuously Operating Reference Stations

Continuously Operating Reference Stations (CORS) collect data for measuring and monitoring the movement of the continental plates so that the reference frame and datum can be defined, improved, and maintained for geoscience and spatial datasets. The advent of Global Navigation Satellite System (GNSS) technology has facilitated the uninterrupted availability of high precision location and time data essential for CORS. Keeping in mind the importance of CORS in the national infrastructure and the role of GNSS in CORS, ISRO organised a webinar on "Continuously Operating Reference Stations (CORS) in India – Prospects of NavIC" during April 21-22, 2021. All the major stakeholders (Survey of India, research institutes including CSIR, academic institutes including IITs, etc.) participated in the webinar and provided valuable inputs for formulating the way forward in India.

b. Very Long Baseline Interferometry

The National Centre for Geodesy (NCG) at IIT Kanpur under the Dept. of Science and Technology (DST), Government of India, has proposed a Very Long Baseline

2.3 Navigation Systems

Interferometry (VLBI) project having national importance. NCG has requested technical collaboration with SAC, NCRA-TIFR, and NPL-CSIR. This project is planned to establish geodetic VLBI stations housing facilities like GNSS, SLR, DORIS. At Mt. Abu and Ponmudi, it is proposed to set up a VLBI antenna co-located with Satellite Laser Ranging (SLR) facility being established by ISRO. The VLBI will be using NavIC based timescale for carrying out precise timing measurements. ISRO had multiple technical discussions with NCG on this project during 2021. ISRO participated in the brainstorming sessions convened by NCG during May 6-7, 2021.

7. NavIC in Standards

a. Maritime

ISRO is working towards the development of the International Electrotechnical Commission (IEC) standard for NavIC based shipborne receiver equipment, with the support of BIS. ISRO prepared the draft IEC 61108-6 standard for NavIC based shipborne receiver equipment and submitted it to the working group.

ISRO also collaborated with European EGNOS to develop a common SBAS IEC standard at L1 frequency, including GAGAN. Draft IEC 61108-7 standard for SBAS is being prepared.

ISRO is working towards developing a generic GNSS receiver performance standard under the International Maritime Organisation (IMO). The draft standard is prepared along with other member states and is ready for submission to IMO sub-committee.

b. Unmanned aerial vehicles

ISRO is working towards the incorporation of NavIC in UAV standards in India under the umbrella of BIS. Draft standards are prepared and are being reviewed with the relevant technical committees of BIS.

2.4 Space Science and Planetary Research Systems

2.4.1 Space Sciences and Planetary Research

The Indian space science exploration programme is engaged in developments for its future space science missions like Chandrayaan-3, Aditya-L1 and XpoSat. Space science research activities are continuously being pursued at premier research laboratories of DOS and feasibility studies are undertaken in several ISRO Centres. Considering the need of widening and empowering basic research in space sciences across the country, novel research projects in space science are being supported at various universities and research institutes. In this connection, an Announcement of Opportunities are issued to encourage and support national research institutes to take up various projects to analyse space science mission data, development of space instrument / payload development and generation of human resources. The major activities carried out under space science and planetary research during 2020-21 are summarised below.

2.4.1.1 AstroSat

AstroSat is India's first multi-wavelength mission dedicated to astronomy. AstroSat completed six years of operation in September 2020. Data from AstroSat are widely utilized for the study of various fields of astronomy, from galactic to extra-galactic and users from all over the world.

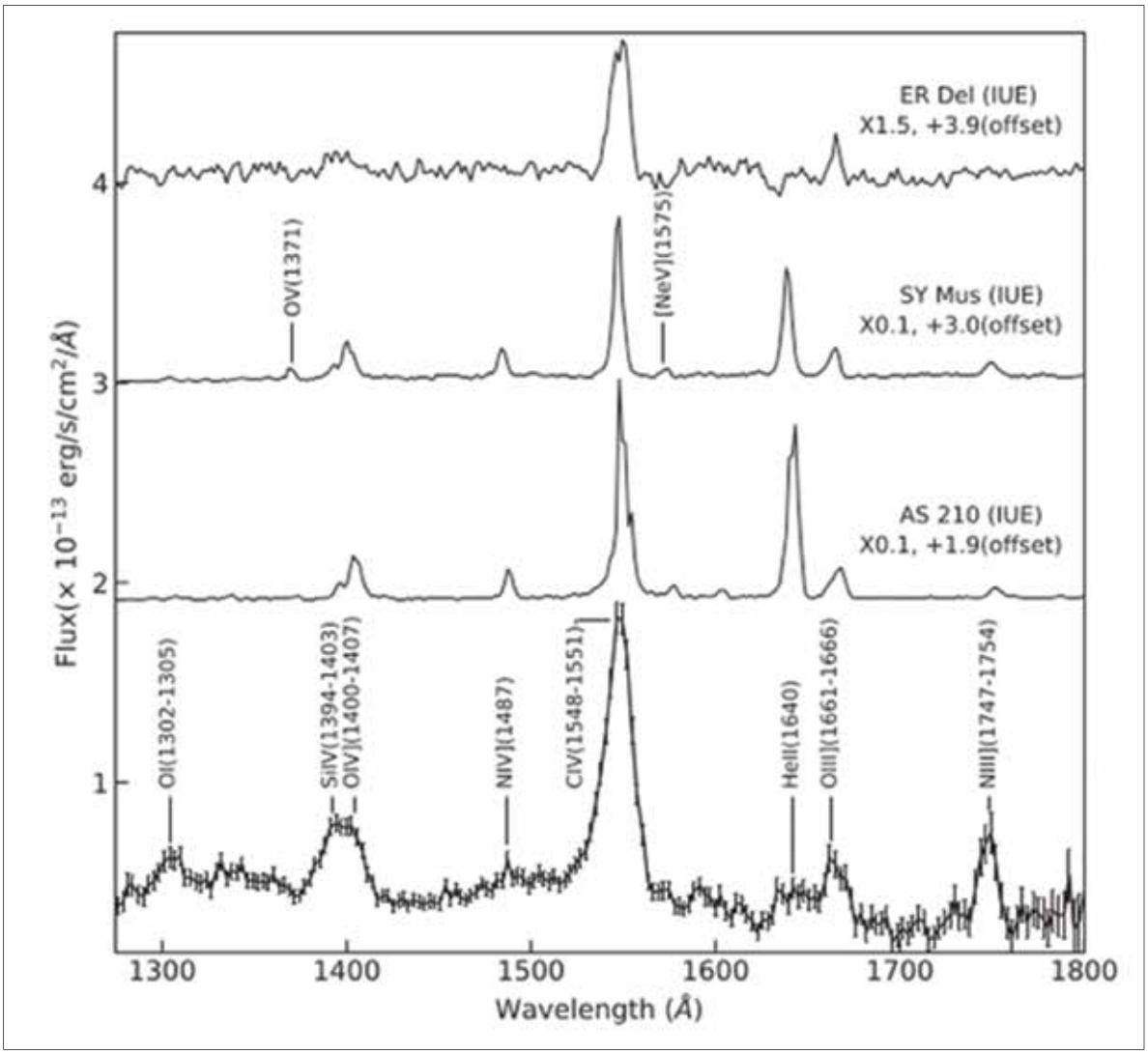
A three-day international conference to celebrate five years of AstroSat was organised in January 2021. The conference was attended by around 140 registered users. A total of 64 presentations, including 12 invited presentations and one popular lecture, were made during the conference. The conference proceedings were live-streamed and close to 425 people watched it live in addition to the conference participants.

AstroSat works as a proposal-based observatory. AstroSat is currently servicing 1530 users from 48 countries. Data from AstroSat has resulted in 86 refereed publications and more than 520 non refereed during 2021. AstroSat has made about 300 unique observations in this timeframe.

2.4 Space Science and Planetary Research Systems

Some of the major AstroSat discoveries/ results during this period are,

1. Discovery of three star-forming galaxies in the Bootes Void
2. Discovery of strong hard X-ray pulsations from Galactic Ultraluminous X-ray Pulsar Swift J0243.6+6124
3. Confirmation of symbiotic nature of a star Su Lyn with UVIT spectrum.



UVIT spectrum of Su Lyn compared to IUE spectra of other known symbiotic stars

2.4.1.2 Mars Orbiter Mission

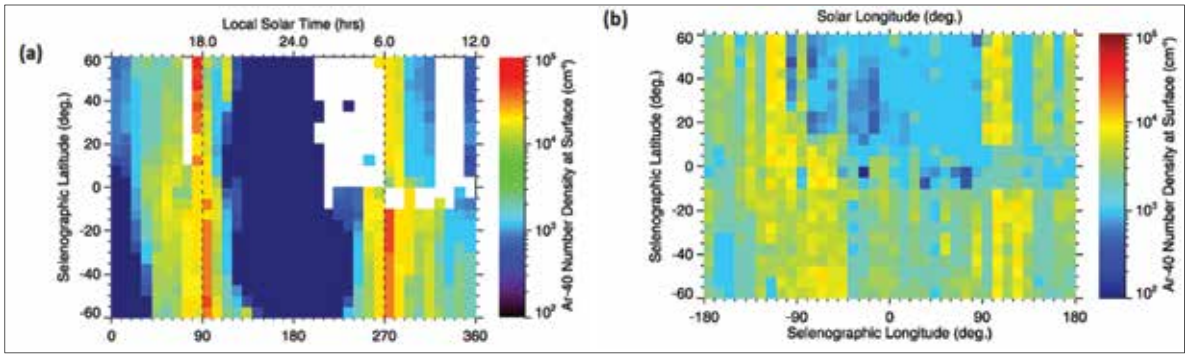
Mars Orbiter Mission (MOM), the first interplanetary mission of ISRO, completed seven years in its orbit on September 24, 2021. MOM data for the period from Sep 2017 to Sept 2020 are made available to the public through ISSDC website: https://mrbrowse.issdc.gov.in/MOMLTA/. More than 7200 users have registered and about 27000 downloads of science data have been carried out so far. Among the registered users, about 400 are international users from 50 countries.

2.4.1.3 Chandrayaan-2 Mission

Chandrayaan-2 Orbiter has completed two years in orbit and the health of the spacecraft and all the eight payloads onboard are normal. Mission manoeuvres were carried out during total lunar eclipse durations and a collision avoidance manoeuvre was performed during October 2021 to mitigate Chandrayaan-2 and NASA's Lunar Reconnaissance Orbiter (LRO) conjunction.

Science results from Chandrayaan-2 payloads were documented and released to the public (https://www.isro.gov.in/files/scienceresultsfromch-2pdf).

CHandra's Atmospheric Composition Explorer-2 (CHACE-2) onboard Chandrayaan-2 orbiter is a quadrupole neutral mass spectrometer aimed at conducting in situ studies of the tenuous Lunar exospheric composition. The CHACE-2 had made in-situ observations of lunar exospheric Argon-40 over the low-latitude regions from a polar orbit and also covered the other latitude regions for the first time.



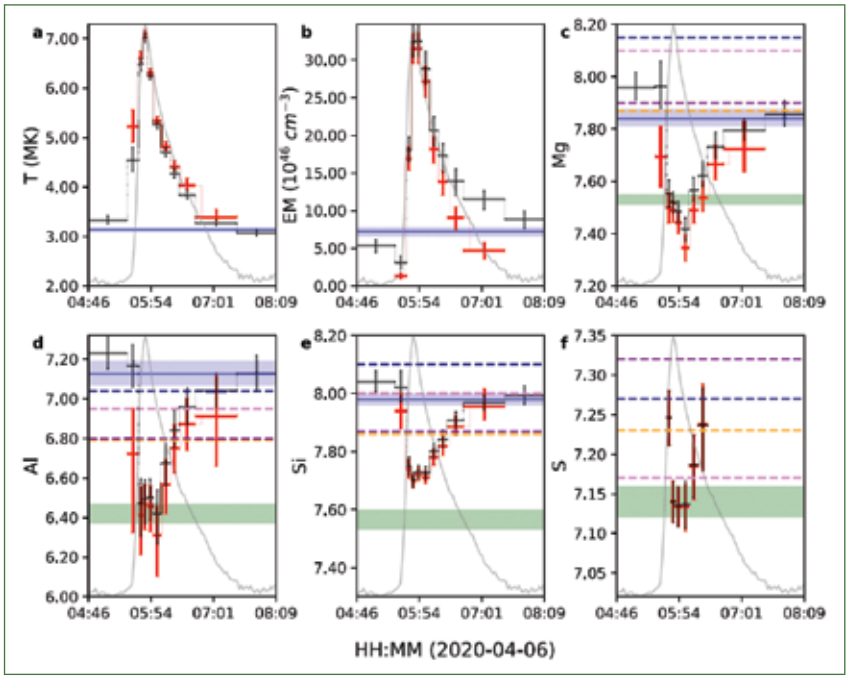
Argon-40 global distribution from CHACE-2 observations, covering both low- and mid-latitude regions

A plausible lobate scarp was mapped by the Terrain Mapping Camera (TMC-2). This NW-SE-oriented scarp is located between Dorsa Geike and Dorsa Mawson. It is estimated that this

2.4 Space Science and Planetary Research Systems

lobate scarp could have been formed in the Copernican period. Image acquisition at a low Sun elevation angle provides the opportunity to map the features having smaller dimensions such as lobate scarps.

The XSM payload has observed nine B-class flares during the minimum phase of Solar Cycle 24. The evolution of temperature, emission measure, and absolute elemental abundances of four elements Mg, Al, Si, and S are examined. These are the first measurements of absolute abundances during such small flares and this study offers a unique insight into the evolution of absolute abundances as the flares evolve.



The six panels show the results of the time-resolved X-ray spectroscopy for a representative flare. Panels a-b show the variation of temperature and emission measure, respectively, during flare activity, whereas panels c-f show the variation of elemental abundances of Mg (c), Al (d), Si (e), S (f) in logarithmic scale.

2.4.1.4 Chandrayaan-3 Mission

Chandrayaan-3 mission is aimed at demonstrating landing and roving on the lunar surface for conducting in-situ sample analysis in the vicinity of the landing site. It consists of a Lander, Rover and Propulsion module. It carries a similar set of payloads as Chandrayaan-2 Lander and Rover. The mission is in an advanced stage of realisation. All the systems in both Propulsion Module and Rover have been realized, integrated and tested. In the Lander Module, most of the systems have been realised and tests are under progress.

2.4.1.5 ADITYA-L1 Mission

Aditya L1 shall be the first space-based Indian mission to study the Sun from a halo orbit around the Lagrangian point 1 (L1) of the Sun-Earth system. This mission, with seven payloads onboard to observe the photosphere, chromosphere and the outermost layers of the Sun (the corona), will provide greater advantage of observing the solar activities and its effect on space weather.

The second and third science meets of Aditya-L1 were conducted during December 2020 and April 2021 respectively, in online mode with more than 70 participants. To support various science users of Aditya-L1, ISRO has also established Aditya-L1 Support Cell in Aryabhatta Research Institute of Observational Sciences (ARIES) through the signing of an Implementation agreement on January 7, 2021.

2.4.1.6 X-ray Polarimeter Satellite (XPoSat) MISSION

The mission aimed to understand the emission mechanism from a variety of X-ray sources. The spacecraft will carry two scientific payloads, POLIX (Polarimeter Instrument in X-rays) and XSPECT (X-ray Spectroscopy and Timing). The primary payload POLIX will provide the polarimetry parameters (degree and angle of polarization) of bright astronomical sources in the energy range of of 8-30 keV photons, while XSPECT will give spectroscopic information of soft X-rays in the energy range of 0.8-15 keV. Both the payloads are at different stages of development.

2.5 Space Transportation Systems

2.5.1 Space Transportation System

Assured access to space is a critical goal for the nation's technological advancement, scientific discovery, security and economic growth. The country has achieved self-reliance in space transportation capability through the operationalisation of Polar Satellite Launch Vehicle (PSLV), Geosynchronous Satellite Launch Vehicle (GSLV) and Geosynchronous Satellite Launch Vehicle – Mark III (GSLV Mk-III) vehicles for launching satellites for earth observation, communication, navigation and space exploration. The Indian Space Transportation scenario is poised to carry forward the self-reliance in launch vehicle technology with enhanced capabilities with respect to payload capability and reusability. The global shift in the satellite market towards small satellite LEO constellations has necessitated the need for a quick turnaround launch-on-demand model, for which the development of a Small Satellite Launch Vehicle (SSLV) was conceived. SSLV is expected to derive commercial benefits along with meeting national requirements, that would primarily be industry-driven during the operational phase. The immense experience derived from the stabilized launch vehicle programmes has enabled the commencement of the human spaceflight programme, wherein a human-rated space transportation system based on the GSLV Mk-III configuration is being realized to transport humans safely to LEO.

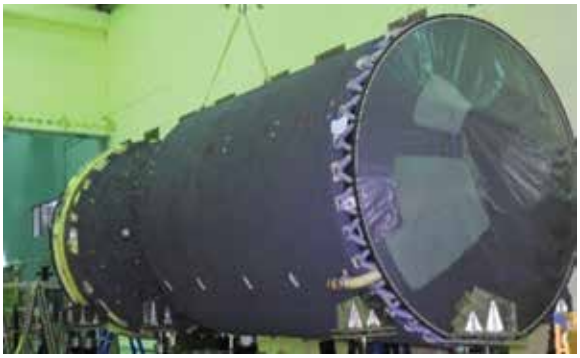
The assured capability to access space and strengthen competitiveness in the international market is being done by bridging the technology gaps and involving industries and academia as major partners in overcoming the challenges by developing innovative techniques and solutions. ISRO is moving ahead with the technologies to scale up both the launch capacity and capability through the development of Semi-cryogenic engines and technology development activities for clustering of liquid engines and reusability of stages.

2.5.2 Major Events

- **Polar Satellite Launch Vehicle (PSLV):** Polar Satellite Launch Vehicle (PSLV) completed its 53rd launch this year and continued to demonstrate its reliability and versatility through multi-satellite and multi-orbit missions, thereby emerging as the workhorse launch vehicle of India.
  - ***PSLV-C51 / Amazonia-1:*** PSLV-C51 successfully launched Amazonia-1 along with 18 co-passenger satellites on February 28, 2021 from SHAR, Sriharikota. The mission was successfully accomplished in 'DL' configuration (third flight with 2 strap-on motors). This was the 78th launch vehicle mission from SDSC, SHAR. PSLV-C51/Amazonia-1 is the first dedicated commercial mission of NSIL, a Central Public Sector Enterprise under DOS. missions of PSLV that are planned to be launched in 2022 include PSLV-C52 / EOS-04, PSLV-C53 / EOS-06 and two dedicated commercial missions for NSIL.

- **Geosynchronous Satellite Launch Vehicle (GSLV):**
  - ***GSLV-F10 / EOS-03:*** The mission was launched on August 12, 2021 as planned. Performance of the first and second stages was normal; however, a technical anomaly occurred in the Cryogenic Upper Stage due to which ignition could not be sustained and the mission could not be accomplished as intended. With respect to the anomaly observed in the GSLV-F10 mission, a National Failure Analysis Committee(FAC) was constituted in order to identify the root cause of the failure. Detailed analysis by FAC has been completed and the root cause of the failure has been identified and simulated in the test bed. Further measures are being adopted to implement the recommendations of the FAC and enhance the robustness of the Cryogenic Upper Stage for future missions.
  - Future missions of GSLV are planned to be launched in 2022 in order to augment the NavIC constellation & to launch the first satellite of the Indian Data Relay Satellite System (IDRSS).
  - ***Geo Synchronous Satellite Launch Vehicle Mk-III (GSLV Mk-III):*** GSLV Mk-III is the next generation launch vehicle of ISRO and is configured as a three-stage vehicle with two solid strap-on motors (S200), one liquid core stage (L110) and a cryogenic upper stage (C25). The second operational mission of GSLV Mk-III (GSLV Mk-III M2) is slated to launch the country's third lunar mission (Chandrayaan-3) in 2022. The solid motor segments for the S200 strap-ons and the core L110 stage have been realised. The integration activities towards realisation of C25 Cryogenic Upper Stage are being carried out.

2.5 Space Transportation Systems



C25 M2 Stage

L110 M2 Stage

- ***GSLV Mk-III-G1 Mission (Gaganyaan Programme):*** Launch vehicle structures of the GSLV Mk-III have been redesigned towards meeting the required human rating factor. Solid motor segments required for a static test towards qualification of HS200 motor have been realized. First sea level qualification test of HS200 igniter completed. Towards qualification of Vikas engine required for Human rated L110 stage, three tests with a cumulative duration of 730 seconds have been completed. Towards qualification of CE20 engine required for C25 stage, 4 short-duration tests (cumulative duration 61.4 seconds) and a long duration hot test for a duration of 720 seconds were successfully conducted. The GSLV Mk-III G1 mission is targeted for launch in mid-2022.

HS2 GAGANYAAN long duration hot test at PTS

- ***Small Satellite Launch Vehicle (SSLV):*** SSLV is an all-solid three-stage vehicle capable of launching mini, micro, or nano class satellites (10 to 500 kg class) into 500 km planar orbit. The vehicle also includes a liquid propulsion-based Velocity Trimming Module (VTM) in the upper stage for precise injection. The first static test of SS1 solid motor was conducted and the performance of SS1 ignition system, propellant system and Flex Nozzle Control (FNC) system was evaluated. Various design modifications have been incorporated to resolve the anomalies observed in the first static test and the second static test (ST-02) is planned for early 2022. The first developmental flight of SSLV (SSLV-D1) is expected in the first quarter of 2022 and two subsequent developmental flights (SSLV-D2 & SSLV-D3) are also planned for the second half of 2022.
- ***Reusable Launch Vehicle (RLV):*** The critical technologies towards the development of a winged body Reusable Launch Vehicle have been progressing through its second phase, wherein the Technology Demonstrator Vehicle (TDV) & associated systems for the Autonomous Runway Landing Experiment have been realized. In this experiment, the TDV will be carried out using a helicopter and released at a distance of about 5 km ahead of the runway with a horizontal velocity. The TDV will demonstrate the approach and autonomous landing capability with landing gear in an air field. Tow tests at different speeds were successfully carried out at the airfield to evaluate the integrated performance of the landing gear and the Navigation, Guidance & Control System after touchdown. Multiple lifting Trials (EMT-2) using helicopters were successfully carried out to demonstrate and verify the performance of the systems prior to the Landing Experiment.
- ***Test Vehicle Project (TVP):*** Test Vehicle is a single-stage launch vehicle based on liquid propulsion being developed to validate the Crew Escape System (CES) performance at different critical Mach numbers. Test Vehicle mimics the Human Rated Launch Vehicle trajectory during its atmospheric regime and uses the already proven L40 earth storable propulsive system with reduced Area Ratio nozzle (AR6.0), modified & new structural elements, new control systems, and the avionics systems in dual-redundant

Tow test at ATR, Chitradurga

Multicopter checks at ATR for Pseudolite system

Engineering model lifting trails

High altitude crane test for RA at SDSC SHAR

Landing Gear: Qualification of Nose Wheel Steering Actuator and MLG Brake Actuator

2.5 Space Transportation Systems

configuration. Out of 6 structural tests planned, 4 tests have been completed and the acoustic testing has been completed. Two vehicles are targeted for realisation in 2022 to meet the CES qualification requirements under the Gaganyaan Programme.

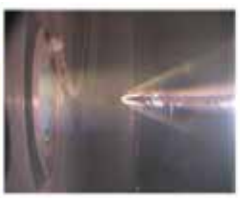
- ***Semicryogenic Propulsion System Project:*** The Semicryogenic Propulsion System Project envisages the design and development of a 2000 kN semi cryogenic engine (SE2000) and stage (SC120), that will enable the development of heavy-lift capability in future Indian Space Transportation Systems. The propulsion system uses a combination of eco-friendly and cost-effective propellants, i.e., Liquid Oxygen and Isrosene (propellant-grade kerosene). The major engine subsystems for the first engine have been manufactured with Indian industry participation and have successfully passed the initial acceptance tests. The integrated engine is expected to be ready for a series of tests by the second half of 2022. The first set of propellant tanks s been realizedin the industry, which has successfully undergone proof pressure tests. Further structural qualification tests are in progress.

- **Air Breathing Propulsion Project (ABPP)**

Development of Critical Technologies for Hypersonic Air-Breathing Vehicle with Air frame integrated system: The Hypersonic Air-Breathing Vehicle is a lifting body hypersonic vehicle integrated with a scramjet engine, boosted to an altitude of 53 km and glide down to 25 km altitude with a Mach number of 6. The objective is to demonstrate the accelerating flight of a hypersonic vehicle with scramjet engine power from Mach 6 to Mach 7 in 250 seconds at constant dynamic pressure. The generated database will be used to design and develop a Two-Stage-to-Orbit vehicle powered by air-breathing combined cycle engine. Several critical technologies have been identified towards the development of the vehicle, including the development of the airframe structures, combustion chamber, actuation system, ignition system, thermal protection systems and the unique high temperature materials required for lining the combustion chamber. The ignition system and the fuel injection struts required for the ground testing of the Scramjet combustor have been realized. Specimen level Thermal Protection System (TPS) for the air intake ramps and the liner for the combustion chamber have been realized and thermal tests are in progress.


Fuel injection Struts


Fuel & GN_2 Manifold assembly


Leading edge thermal test [20s for heat flux of 340 W/cm^2]


ZrC coated C-SiC coupon


Water calibration of strut injector

- **Advanced Technology Vehicles Project (ATVP):** Advanced Technology Vehicle Project is responsible for the development & launching of sounding rockets for the scientific exploration of the middle & upper atmosphere and the realisation of new vehicles to support the demonstration of advanced technologies. It provides a cost-effective platform for testing new technologies before induction into launch vehicles.

- **Rohini Sounding Rocket flights:** A total of 9 RH-200 rockets were successfully launched during this year from TERLS range. So far, 192 consecutively successful launches of RH 200 rockets have been conducted.

- **Sounding Rockets Experiment (SOUREX) Programme:** The maiden flight of the RH560MkIII Sounding Rocket took place from SDSC SHAR at 19:15 hrs. IST on March 12, 2021, to investigate the post-sunset thermosphere-ionosphere under Phase-II of the SOUREX programme. It successfully expelled the pyrophoric liquid Trimethyl Aluminum (TMA), creating a chemiluminescent trail at altitudes between 96 and 155 km, meeting the mission objectives. The TMA trail was observed from stations located at multiple geographic locations.

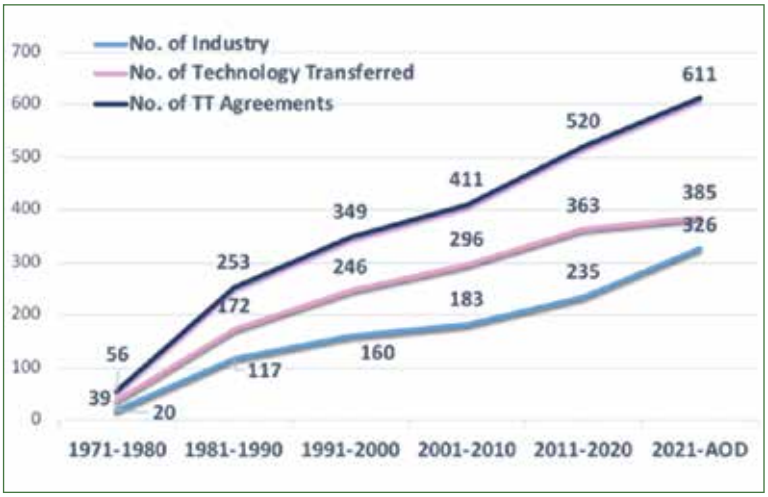
- **RH300 MkII /Inflatable Aerodynamic Decelerator (IAD) Technology Demonstration:** IAD is configured as a stacked toroid (gas barrier layer and external aerodynamic cover). Configuration & mission studies were carried out and inflation & packing trials were completed. Realisation of flight systems are in progress. The propellant casting of RH300MkII motor for IAD demonstration flight completed.

2.6 Capacity Building

ISRO undertakes various capacity building activities like advanced technology developments towards indigenisation, human resource development through various training programs, collaborative research with academia, industry and research institutes, technical facility & infrastructure development, partnering with industries for technology transfer and MoU with government entities & other reputed institutes for sharing technology know-hows.

2.6.1 Technology Management

2.6.1.1 Technology Transfer



ISRO developed critical technologies for various space applications which have got commercial value for the spin-off and other applications. ISRO has transferred more than 385 technologies to around 326 industries across India so far and resulted in 611 agreements. As per the recent reforms announced by the Government of India, the responsibility of commercializing the ISRO technologies was entrusted to NSIL (the commercial arm of DOS).

Further, ISRO has already transferred around 69 technologies to M/s NSIL during 2021.

ISRO is also revising the technology transfer policy to enable the industry to participate more in the space programmes of the country, including joint development, IPR management and self-reliance.

ISRO also collaborates with AGNII, Invest India teams, ministries such as MSMEs and heavy industry to propagate the technology transfer programme to reach the potential industry.

2.6.1.2 Intellectual Property Rights

ISRO has around 178 active patents, 71 Nos. of copyrights and 13 Nos. of trademarks. During the reporting period, around 25 patent applications and 5 copyright applications are filled, 34 fresh patents were granted and active patents were renewed. Presently, 97 Nos. of patent applications are under various stages of examination and 18 are undergoing drafting by the patent attorneys before their eventual filing at the patent office. Internationally, one PCT application has been granted. 5 Nos. of fresh copyrights were granted to DOS related to the software category. ISRO's active IPRs have been updated and made available on the ISRO website.

2.6.1.3 Indigenisation

ISRO has internal deliberations within the ISRO centres and prepared indigenisation manifest in both electronics and materials with the list of items proposed to be indigenized during the next 2-3 years. Separate interactions were held with ISRO centres to prepare the list of ASIC – Application Specific Integrated Circuits and Sensors. The technical documents were brought out for the benefit of facility in charges to make use of developments across the organisation and for inducting them into space programmes. The relevant hardware, which is potential for commercialisation and spin-off applications will be identified and transferred to the industry for productionisation.

2.6.2 Academia Interface and Sponsorship Research

2.6.2.1 RESPOND

ISRO started the RESPOND (Sponsored Research) programme in 1970s, with the objective of encouraging academia to participate and contribute in various Space-related research activities. Under RESPOND, projects are taken up by Universities/Academic Institutions in the areas of relevance to the Space Programme. ISRO has evolved the RESPOND programme through which necessary financial and technical support is provided to academia in India for conducting research and development activities related to Space Science, Space Technology and Space Applications. This is the flagship programme of ISRO to promote extra-mural research in emerging areas of Space at Academia.

2.6 Capacity Building

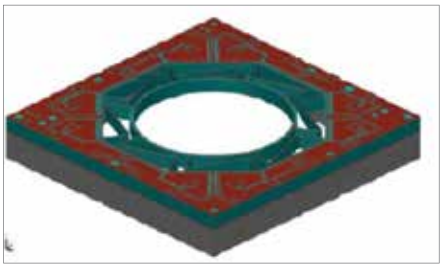
During the period, RESPOND supported 36 New Projects and 82 ongoing projects and R & D activities of nine Space Technology Cells and six Regional Academic Centre for Space. During the year, 22 sponsored projects have been successfully completed. Scientific publications have been emerged out of these projects apart from fulfilling the objectives.

During the year, 42 Universities/Colleges, 21 IITs /NITs and 8 Research Institutes/ Laboratories were involved in R & D projects . Further, during the year, a large number of projects have been supported in the area of Space Technology (86) followed by Space Application (25) and Space Science (7).

Highlights of Some of the completed RESPOND Projects

- **Design and Development of Ring Resonator for Coriolis Gyroscope using Micro Machining Technology.**

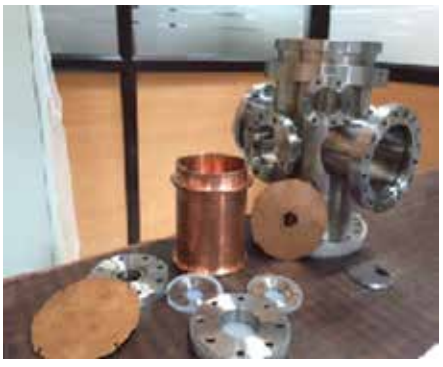
  This project aims at the realisation of MEMS structured realisation of solid-state ring resonator Coriolis Rate Gyroscope (CRG) for ISRO Inertial Systems Unit. The proposal successfully completed the fabrication and structural as well as electrical integrity testing of the ring resonator. Two design variants of a sensing element for silicon Ring structure-based Coriolis Gyroscope were designed.



Ring resonator

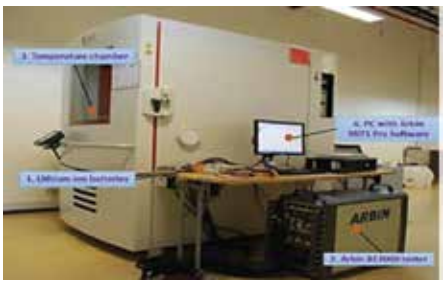
- **Probing interstellar and atmospheric anions through velocity map imaging.**

  Under this project, Velocity Map Imaging Spectrometer was designed and built. Time of flight mass spectrometer, ion source and mass gate were also built to perform studies on Interstellar molecules and ions. Formation of the larger molecule upon multiphoton ionisation of quinolone and isoquinoline were discovered.



- **Modeling and performance prediction of Lithium Ion Cells.**

  This project is aimed to design and develop algorithms for predicting the performance



degradation of the batteries with Li-Ion Cells. The project has successfully developed a model that can be used to predict the life of Li-ion battery used in spacecraft.

- **Design, modeling and simulation of GaAs based III-V semiconductor multi-junction solar structures for space applications.**

  Under this project, a model for triple and multi-junction solar cells with III-V semiconductors was developed. The project has helped in gaining the understanding of triple-junction solar cell structure, which in turn helps in the growth and development of indigenous solar cells.

- **Conformal array synthesis using evolutionary algorithms for the generation of a shape beam antenna for data transmission.**

  This project aims at the generation of shaped beam antenna patterns on conformal shape at C and X band. The major outcome of the project includes the synthesis of cosecant square-shaped beam antenna pattern using differential Evolution & Simplified Swarm optimisation (DE-SSO), derivation of array factor on a conformal surface with proper orientation of element pattern in the desired direction. This shaped beam antenna pattern will help avoid the need for sensitivity time control correction required in SAR processing.

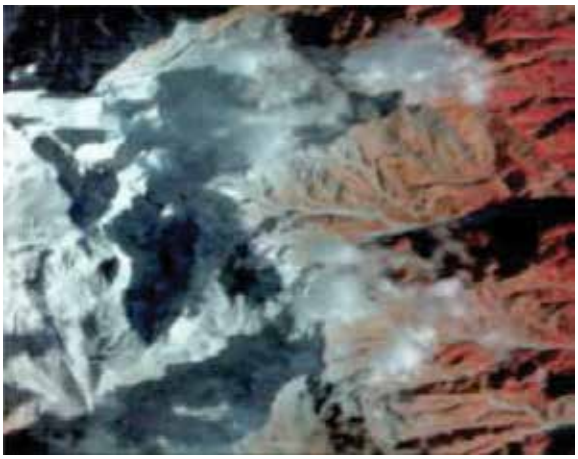
- **Design of a multiband and polarization –Sensitive Smart Antenna using SVM based DOA Estimation Techniques and Genetic Algorithm-based optimization for Indoor positioning.**

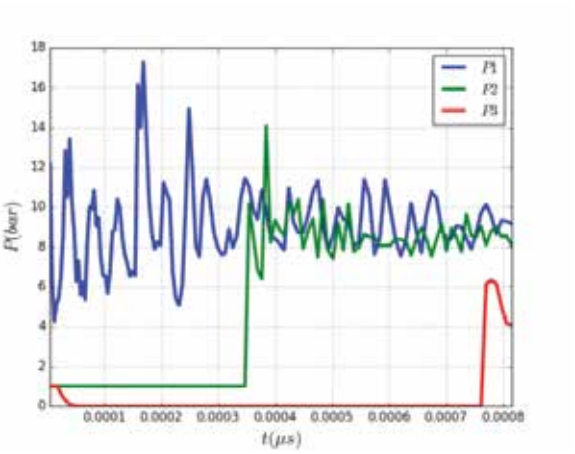
  This project aims at the design of a smart antenna system, commuting the Direction of Arrival (DOA) of the received signal for C-band by using the Radio interferometry technique. Under this project, the Sinuous Array System (SAA) has been designed for the L-band applications and has been fabricated successfully.

- **Integration of spectral and spatial information for hyperspectral image classification.**

  This project aims to develop new/improve existing methods /algorithms for spectral-spatial classification of Hyper Spectral Imagery (HSI). Under this project, five spectral-spatial classification methods based on deep learning models were developed.

2.6 Capacity Building

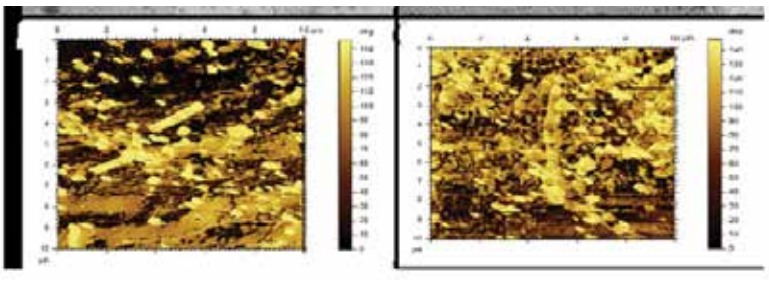




- **Experimental and Numerical Studies on Pulse Detonation Rocket Engine.** This project aims at the experimental and computational study of the Deflagration to Detonation Transition (DDT) in pulse detonation rocket engine. A 2D axisymmetric model with rectangular obstacles was designed and numerical simulations were carried out for different equivalence ratios.

  The experimental observations were considered for the design of in–house pulsed detonation rocket engine.

- **Advanced high strength conjugated polymer-based conductive fibers as a smart textile material for space applications.**



Under this project, intelligent cotton fabric was fabricated using a multidimensional approach including a non-iconic surfactant-based micro structured carbonaceous coating. The "Knife-over-roll "technique along with the "dip-coating strategy" was used for the same. The developed novel fabric was flexible and mechanically robust.

2.6.2.2 ISRO ACADEMIA Day - 2021

ISRO has always looked for greater participation and contributions from academia in a focused manner for the timely accomplishment of its objectives.

Considering the ongoing involvement of academia in ISRO activities and to enhance the collaboration to newer areas, ISRO Academia Day-2021 was organized. It was organised through virtual mode on January 07, 2021. ISRO Academia Day-2021 aimed at providing a common platform to Academia as well as the scientific community of ISRO to share their knowledge experience and create awareness about the opportunities available in ISRO for the promotion of Space Science & Technology, Education and Research. Two technical documents, RESPOND Basket 2021 and Research Areas in Space 2021, were released.

2.6.2.3 Space Technology Cells (STC)

ISRO has set up nine Space Technology Cells (STC) at premier institutions like Indian Institute of Technology (IITs) - Bombay, Kanpur, Kharagpur, Madras, Guwahati, Roorkee and Delhi; Indian Institute of Science (IISc), Bengaluru and Joint Research Programme with Savitribai Phule Pune University (SPPU, Pune) to carry out research activities in the areas of space technology and applications.

During the period, ISRO has supported 66 new projects and 121 ongoing projects pertaining to nine Space Technology Cells. Under STCs, 46 projects have been successfully completed during the year.

Details are given in the table below:

Sl. No	Name of the STC/JRP	No. of Projects		
		New	Ongoing	Completed
1.	IISc Bengaluru	15	20	7
2.	IIT Bombay	1	17	8
3.	IIT Kanpur	Nil	22	9
4.	IIT Kharagpur	10	22	6
5.	IIT Madras	12	20	6
6	IIT Roorkee	13	Nil	Nil
7	IIT Guwahati	4	Nil	Nil
8	IIT Delhi	8	Nil	Nil
9	SPPU, Pune	3	20	10
	Total	**66**	**121**	**46**

2.6.2.4 Regional Academic Centre for Space (RAC-S)

Also, under the Capacity Building Programme Initiatives, ISRO has set up 6 Regional Academic Centre for Space (RAC-S) at MNIT, Jaipur (Western region), Gauhati University, Guwahati

2.6 Capacity Building

(North-Eastern Region), NIT Kurukshetra (Northern Region), NITK Surathkal (Southern Region), IIT(BHU) Varanasi (Central Region) and NIT Patna (Eastern Region). RAC-S aims to pursue advanced research in the areas of relevance to the future technological and programmatic needs of the Indian Space Programme and act as a facilitator for the promotion of space technology activities among students in the region. This will also inculcate scientific temper in the student community and will allow them to work in the advanced fields of research. RAC-S will also facilitate and engage other institutes of excellence in the region to take part in the capacity building, awareness creation and research & development activities.

Under the Regional Academic Centre for Space programme a total of 13 projects have been supported during the year. This includes MNIT Jaipur (4), Gauhati University, Guwahati (3) and NITK Surathkal (6). The projects are reviewed by domain experts in ISRO and later by Joint Policy Committees consisting of experts from ISRO and academia.

New Regional Academic Centres for Space (RAC-S) inaugurated at IIT (BHU) Varanasi and NIT Patna

Regional Academic Centre for Space (RAC-S) is a regional level initiative to pursue advanced research in the area of space technology, space science and space applications relevant to the space programme. It aims to encourage student centric research activities in the region. ISRO signed an MoU with the Indian Institute of Technology, Varanasi on December 23, 2020 for setting up of the 5th Regional Academic Centre for Space in the country. The MoU for setting up of the 6th Regional Academic Centre for Space at NIT Patna was also signed on November 25, 2021.

2.6.2.5 Space Technology Incubation Centres (STI-C)

This will enable the young academia to realise their innovative ideas/research aptitude into space-grade components/elements that can be utilized for space applications and guide them towards setting up the start-ups. These future start-ups will have the potential to create job opportunities. To moot this concept, ISRO has established six Space Technology Incubation Centres (STI-C) at six NITs across the country. The six locations are (1) National Institute of Technology, Agartala (for North-Eastern region), (2) Dr. B R Ambedkar National Institute of Technology, Jalandhar (for Northern region), (4) National Institute of Technology, Tiruchirappalli (for Southern region), (4) Visvesvaraya National Institute of Technology, Nagpur (for the Western region), (5) Maulana Azad National Institute of Technology, Bhopal (for Central region), (6) National Institute of Technology, Rourkela (for Eastern region) for setting up the Space Technology Incubation Centre in their campus.

YUKTI - Sanchita 2021:

Dr. K. Sivan, Chairman ISRO / Secretary DOS, also released YUKTI-Sanchita 2021 (Youth Upgradation by Knowledge Transformation through Incubators - Sanchita), a compilation of 108 Product Development / Innovative Project Proposals from Centres / Labs/ Units of DOS/ ISRO on the occasion of inauguration of three new S-TICs.

This is one of the major steps by DOS / ISRO to achieve the development and indigenisation of space-grade components/products / processes in tandem with objectives of Aatmanirbhar Bharat.

Incubation Activities:

A total of 23 Technology Development Projects (TDPs) related to ongoing Space Science and Technology are progressing satisfactorily at Space Technology Incubation Centres, out of which 7 projects are nearing completion. 22 new Product Development / Innovative Project are also in the review and approval phase for S-TICs. Suitable experts from various ISRO / DOS Centres / Units / Labs are continuously mentoring the students and providing valuable inputs to faculty members associated with the activities related to these TDP's. The progress of TDPs is reviewed quarterly and necessary guidance and technical supports are provided as and when required.

In 2021, S-TIC has created a remarkable impact by providing on-hand expertise to more than 250 students of various engineering disciplines for state-of-the-art technical incubation and product development activities related to Space Science and Technology.

2.6.2.6 Centre for Nano Science and Engineering

The collaboration with Centre for Nano Science and Engineering (CeNSE) at IISc caters to the requirements of ISRO in the areas of nanotechnology and nanoscience. The Centre is providing support for the R & D activities, utilisation of nanofabrication and characterisation facilities by the various centres of ISRO, in addition to training/capacity building.

2.6.2.7 Centre of Excellence (CoE) on "Advanced Mechanics of Materials"

Further, in order to enhance greater participation and contributions from academia in addition to the ongoing Respond activities, a Centre of Excellence (CoE) on "Advanced Mechanics of Materials" has been set up at IISc. The Centre aims at pursuing advanced research in the areas of materials, especially on nonclassical continuum mechanics and Geometric and data-driven models for space applications.

2.6 Capacity Building

2.6.2.8 Veer Surendra Sai Space Innovation Centre, VSSUT

ISRO has signed an MOU with Veer Surendra Sai Space Innovation Centre, VSSUT, Burla, Sambalpur, Odisha for carrying out research and building capabilities for launch vehicles and satellites within the institute.

2.6.2.9 Centre for Space Science, JAMMU & KASHMIR

In addition to this, in order to enhance infrastructure requirements for Space Science activities in the Jammu & Kashmir region, an MoU has been entered into with Central University of Jammu to establish a centre for Space Science. The centre will also take care of the emerging Geospatial and Space technology requirements for the development of the region.

Also, conferences, workshops and publications, which are of relevance to space programme, are also being supported.

2.6.3 Outreach Activities

2.6.3.1 International Space Conference and Exhibition:

A three-day virtual International Space Conference and Exhibition [ISCE], in collaboration with CII, NSIL and Antrix, was conducted with the involvement of all ISRO centres during September 13-15,2021. Secretary, DOS / Chairman, ISRO delivered the special address in the inaugural session. The event was streamed across ISRO centres through intranet as well as to the general public through the CII YouTube channel.

2.6.3.2 International Astronautical Congress (IAC-2021):

International Astronautical Congress (IAC-2021) was organized in Dubai during October 25 – 29, 2021. ISRO participated and established a pavilion by showcasing achievements and future programmes of ISRO. It facilitated technical presentations, bilateral meetings with other national space agencies and business connections with the international space industry to explore future opportunities for collaborations. Secretary, DOS / Chairman, ISRO and senior officials of DOS participated in the event.

2.6.3.3 World Expo -2020, Dubai:

DOS participated in the Dubai World Expo-2020 at Dubai. ISRO curated the concepts and finalised the gallery displays for Space Pavilion in collaboration with Dept. of Commerce, which are exhibited for six months from October 1, 2021 to March 31, 2022. Space week was organised at Indian Pavilion, World expo from October 17-23, 2021. ISRO developed digital content on various present & future missions and achievements of ISRO and screened throughout the week and interacted with visitors and students visiting the gallery. ISRO organised technical sessions along with FICCI involving multiple space agencies and industries. Various Directors of ISRO centers delivered keynote addresses and participated in panel discussions in five sessions. ISRO team also interacted with various foreign space agencies on call and discussed potential collaborations with industry and academia.

2.6.3.4 Merchandise Programme:

Customized ISRO-theme-based products can play a game-changing role in creating awareness and kindling interest of the students, children and public in the domain of space science & technology, propagating the achievements and laurels that ISRO brings to the nation. An Announcement of Opportunity has been floated in this regard, where interested agencies were invited to apply to register for ISRO merchandisers.

On July 29, 2021, Secretary, DOS/Chairman, ISRO formally launched the ISRO-theme based merchandise program in a virtual event in the presence of Scientific Secretary, ISRO, with the selection of the first batch of registered ISRO merchandisers. 23 parties have submitted proposals to become ISRO registered merchandisers and 13 parties have signed an MoU with the Department for developing & marketing of ISRO-theme based products.

2.6 Capacity Building

2.6.3.5 Indian International Science Festival (IISF -2021)

IISF-2021 organised by the Ministry of Science & Technology and Ministry of Earth Science in association with Vijnana Bharati and State Govt. of Goa during December, 10 - 13, 2021. ISRO extended technical support for oragnising assembly & launch of a model rocket by school students. Around 550 students gathered, assembled model rockets and launched 498 no. of model rockets successfully and made Guinness book of records. ISRO also established an exhibition stall, showcasing ISRO's achievements and future programmes. The space on wheels was the centre of attraction for the students. ISRO bagged the best participation award.

2.6.3.6 Atal Tinkering Lab (ATL) Space Challenge 2021:

Atal Innovation Mission (AIM), NITI Aayog in collaboration with the ISRO and Central Board of Secondary Education (CBSE) launched the ATL Space Challenge 2021 for all school students across the country. The ATL Space Challenge 2021 aligns with the World Space Week 2021, which is being observed from October 4-10 each year at the global level.

The challenge has been designed for all the school students, mentors and teachers across the country. This is to ensure that students of classes 6 to 12 are given an open platform where they can innovate and enable themselves to solve digital age space technology problems. Around 600 students have submitted their projects and evaluation of the projects is in progress.

2.6.3.7 Rising Uttar Pradesh Conference

Setup a stall and projected the ISRO programmes at the rising Uttar Pradesh conference and awarded the best stall as a part of Azadi Ki Amrit Mahotsav. The stall was managed by ISRO Branch Secretariat, New Delhi.

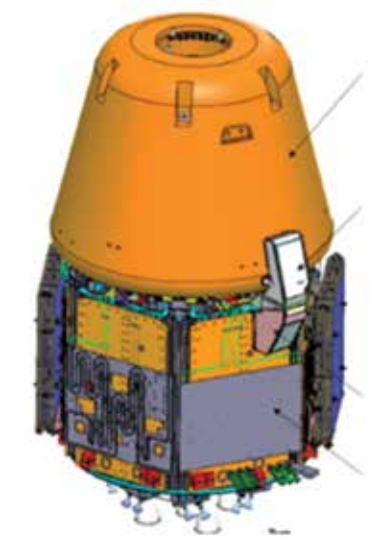
2.6.4 Other Outreach activities

- AT IIRS, IIRS distance learning programme is an innovative approach of mass-scale capacity building on Remote Sensing, GIS and GNSS technology and its application. Under this programme network of 3021 institutions in India is set up, out of which 1476 Institutions joined the IIRS outreach network in 2021. IIRS conducted various online courses in 2021 specially targeted for students and professionals in Work from Home (WFH) condition during the pandemic. Total 28 online courses/workshops were successfully conducted during April 2021 to December 2021 by using ECLASS platform (https://eclass.iirs.gov.in) indigenously developed at IIRS. These courses include 05 special courses during COVID-19 lockdown period and 06 online courses on various advanced topics on Remote Sensing technology and its applications, 02 International and 01 National Webinar Series, 06 Basic Courses on RS&GIS technology & applications and 02 Special Customized Course In addition to that 6 full-day online workshops. IIRS received excellent responses from across the world, where 245164 participants got benefitted from these online programmes. Out of which, 178705 participants attended the online courses and 41590 participants successfully completed the courses and awarded with a certificate.

- At NRSC, several courses were conducted to the staff of Central, State and Academic Institutes on the promotion of Remote Sensing and Geospatial technologies. Due to the prevailing COVID 19 scenario, online programmes were conducted till September 2021. A total of 23 programmes for 931 personnel were conducted for the Engineers of National Hydrology Project, Defence Estates personal and other on Bhuvan, Open Source GIS, Geospatial Technologies for Climate Studies, RS & GIS applications in Water Resources and Disaster Management. A total of 37665 participants (Students from Schools, Colleges and Public) visited the exhibitions of the Outreach facility both online as well as offline.

2.7 Gaganyaan – Human Space Flight

Gaganyaan Programme is aimed at accomplishing Human Spaceflight capability, which is a key milestone for Indian Space Programme. The objective of the Human Spaceflight Programme is to undertake a human spaceflight mission to carry a crew of three to Low Earth Orbit (LEO) and return them safely to a predefined destination on earth. The programme is proposed to be implemented in a single phase with 2 un-crewed missions [G1 & G2] followed by a manned mission [H1]. Critical technologies that are needed to undertake human spaceflight are the development of the Crew Module (CM) System, Crew Escape System (CES) and Environmental Control and Life Support System (ECLSS). The GSLV Mk-III vehicle with Human rated systems termed as HRLV is identified for the Gaganyaan mission.



Orbital Module

The objectives and configuration for the first unmanned mission [G1] have been defined. The design of the Orbital module (OM) consisting of both the Crew module and Service module has been completed and all fabrication drawings are generated. Action has been taken concurrently for the procurement of raw materials for its various systems. The realisation of sub-assemblies has been initiated. Propulsion system configuration has been finalized and realisation is in progress. System demonstration tests towards qualification of propulsion system have been initiated and 5 ground tests have been completed for service module propulsion system.

The Human Rated Launch Vehicle (HRLV) design has been completed and hardware realisation is in the advanced stage both for ground qualification tests and for the 1st unmanned mission. A series of qualification tests have been planned for the stage systems and certain tests have been completed. The Crew Escape System (CES) design has been completed. Raw materials have been procured for a majority of the systems. The realisation of 3 sets of

Human rated vehicle

hardware namely, for qualification tests, TV-D1 Mission & for G1 Mission is taken-up parallelly through multiple vendors and realisation is nearing completion. Qualification tests for the crew escape system solid motors are initiated and static tests of 2 Nos. of motors have been completed.

The ground infrastructure, especially the facilities required at launch complex for the mission, is getting ready. Plans are also in place for ensuring end-to-end communication throughout the mission by establishing a ground stations network for telemetry, telecommand and tracking (TTC) through the identification of various ground stations across the globe.

The four Indian astronauts have successfully completed generic space flight training at GCTC, Russia and returned to India. The scheme for the Indian leg of training has been devised. An astronaut training facility in India has been established. The Indian leg of training has been initiated. Human rating certification activities are progressing parallelly.

Mission

Crew escape system characterisation through Test Vehicle mission: The mission definition and vehicle data document (Crew module related) for TV D1 mission was completed. The CM DAP design for TV D1 mission has been reviewed and cleared by DRT-G (NGC D&V). The autonomous test bed for end-to-end mission simulation is nearing completion. The requirement of Monte Carlo Simulation for TV D1 mission and inputs for CM phase provided.

First Unmanned mission, G1:

The specification for injection parameters for HRLV was revised from 170 x 395 to 170 x 408 km in-order to ensure adequate propellant margin in the SM propulsion system. The circularization manoeuvre is planned to be carried out in third orbit apogee instead of fourth orbit in order to reduce the residency period of the perigee to a lower altitude of 170 km. A Mission Interface committee was constituted to review and finalize all the data flow interfaces between all the participating entities/teams in the ground segment. The different types of SNAP (separation) scenarios that are possible in the overall mission (H1 – Crewed mission) were identified, for which different sequences of operations are worked out depending upon the separation scenario. Mission plans for touchdown in the Indian waters under nominal and contingency scenarios have been worked out.

The corresponding communication network availability for the different options was also worked out. Mission sequence documents for the descent phase in TV-D1 and G1 missions were finalized for on-board implementation. The various touch-down locations for nominal

2.7 Gaganyaan – Human Space Flight

descents, ascent phase aborts and on-orbit phase aborts were worked out as per the latest mission plan and presented to Inter-Agency Committee for Recovery Operations (ICRO). The requirements for communication equipment on-board the recovery ships for ensuring real-time communication with the mission control centre were also presented.

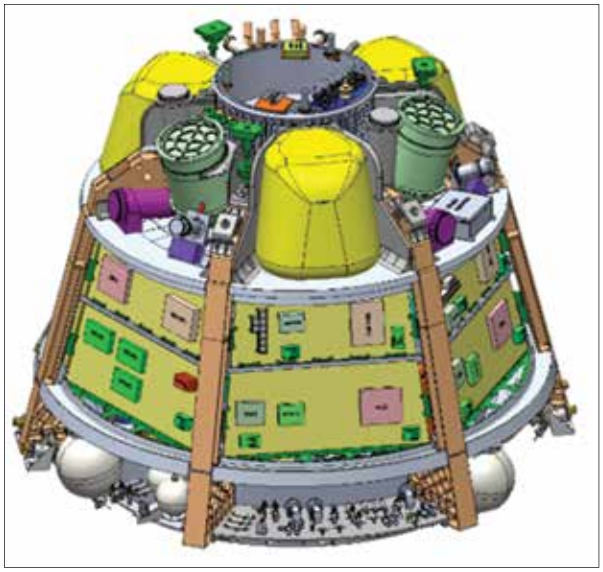
OM Control and Simulations: Detailed propellant budget and failure tolerance conditions were worked out for the revised OM configuration and latest mission plans. Control disturbance and propellant consumption studies for the symmetric and asymmetric solar panel configurations were studied. The firing profiles for the LAM engines and RCS thrusters for nominal and contingency conditions were generated and provided to the propulsion team for the Service Module System Demonstration Model (SM-SDM) test. Mission Profile Documents for LAM engines and CM and SM RCS thrusters were released. All types of mission simulations, including HRLV, OM, ECLSS, DGA pointing and Crew Training, were identified and various configurations for these have been worked out.

Orbital Module [OM]

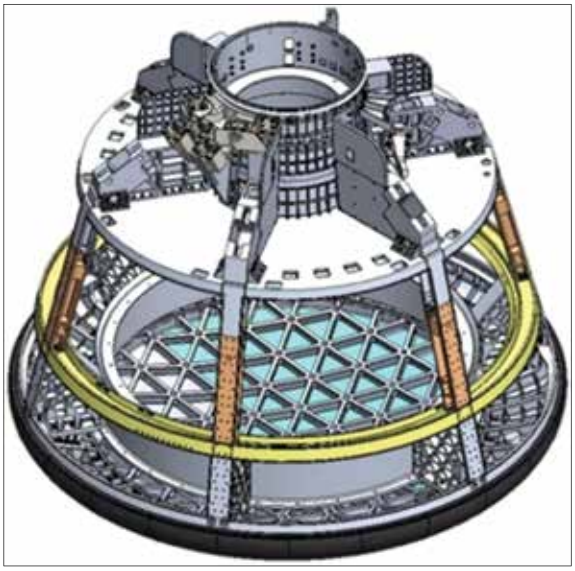
Crew Module [CM] for TV & G1 Mission:

System Engineering: Crew Module accommodates subsystems like Aero thermal structure, ECLSS, Propulsion system, Parachute & Separation systems, Avionics, Power and Communication system, Crew auxiliary systems like Crew seat, Hatches and Viewports, and Crew console which consists of display units and alert/command buttons. The structure has been designed considering two configurations namely, Unpressurised Crew module for the first unmanned mission, G1 and Test vehicle and Pressurised CM Inner structure for second Unmanned, G2 and Manned mission, H1.

For both versions, outer & inner mould lines were defined. Inputs and requirement documents generated for each of the Crew module subsystem design. Configuration and accommodation/ layout of subsystems like Apex cover, Parachutes, Propulsion, Avionics, Up-righting system, Separation system, Crew seat assembly has been carried out accounting inter and intra-dependencies between systems. Except for ECLSS system, all the functional systems have been retained, the same as in H1 for the first unmanned mission, G1. Detailed inputs were provided for the interface design of the above systems. Based on GIRESH recommendation, CG of the Crew module has been revised for nominal and abort missions. Accordingly, mass properties of the Crew module and combined Orbital module (with SM mass property input) were generated for various mission studies.



Crew Module - System Engineering

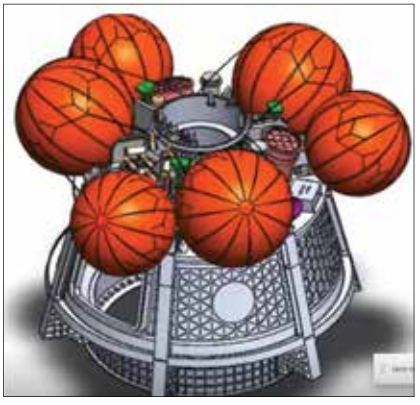


Crew Module Inner Structure

In CM unpressurised structure, Apex compartment & Aft heat shield dome is maintained same as in H1 mission. Aft diffuser ring is introduced in the shoulder ring to take care of the dome deflection upon impact in the sea for G1. The external structure is configured with metallic conical panel accommodating all antennas, cut-outs for hatches, RCS thrusters & CS-CDS for G1.

CM External Structure

Separation System: The CM-SM umbilical (CS-CDS) is configured with a 2 plane separation system with an Auto sealing device for ECLSS Oxygen and heat exchanger lines and electrical connectors for transfer of electrical signals, power, pyro commands from CM to SM and vice versa. Assisted separation force connectors (ASF) were realised, and functional demonstration test of the same has been carried out.



CM Up righting system

Up-righting system: Considering two stable orientations (6° and 170° from vertical) for CM after a touchdown in the sea, the Crew Module Up-righting system is designed to maintain CM in a mono-stable position. 6 Inflatable floats (3 Nos. primary and 3 Nos. secondary floats) are

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planned and are accommodated as packed units in the Apex region of CM. GIRESH Committee recommended developing a Pyro-based cold gas generator system (as an alternate option) for inflating the floats upon touchdown in place of the conventional gas storage system. The design for pyro based gas generation system is being worked out.

Avionics & AIT: Triple redundant Avionics system is proposed for the Unmanned and Manned missions and dual redundant avionics are configured for the Test Vehicle Crew module. Avionics are accommodated inside CM. Harness Jigs/ Integration mock-ups/ fixtures for handling/ transportation are realised. For the manned mission, CM inner structure is a pressurised structure and additional systems like Environment control & Life Support System (ECLSS), Green prolusion, Viewports, Ingress/Egress side hatch and forward hatch are configured.

TV/G1 Propulsion systems: CM propulsion system is configured with 12 Nos. of Bi-propellant RCS thrusters at the leeward side of CM. The required propellant tanks, gas bottles, propulsion deck with control components, fill & drain valves are configured and accommodated in the Aft annular region of CM. Hardware realised for 3.5 m is used for the System demonstration module test of the CM Propulsion system. Test article with propulsion system is under final integration at LPSC-V. Finalized the locations of the CM RCS thrusters and verified the satisfactory control requirements w.r.t mission simulations. Fabrication completed for major components namely, gas bottle, propellant tanks, 100 N RCS thrusters, FCVs & ILVs. Assembly of various components is in progress.

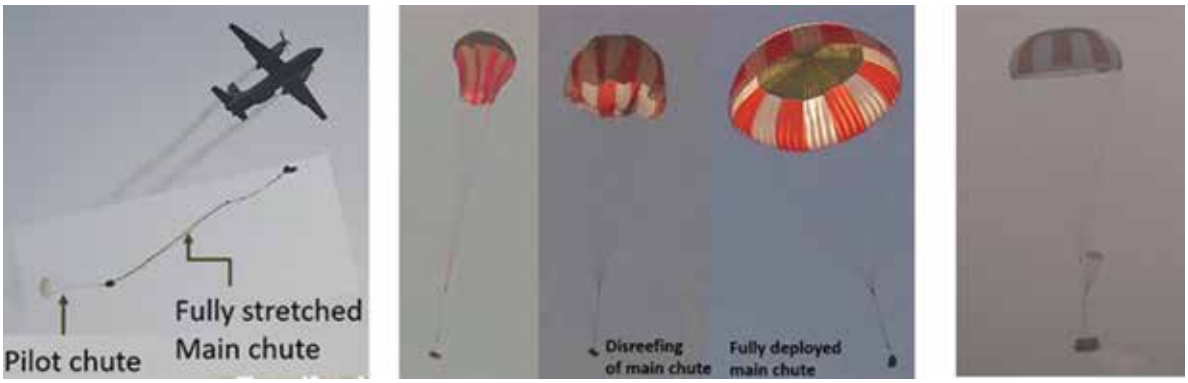
Green mono propellant based 100 N RCS thruster

H1 Propulsion systems: Finalized the propellant combination for CM H1 mission i.e., mono green propulsion (H_2O_2 with catalyst). The configuration layout has been finalized and cleared in SRC-OMPS. Realized 3 Nos. of 100 N thrusters with H2O2 and successfully completed hot tests with satisfactory performance. Carried out accommodation studies of mono-green propulsion system in H1 Crew Module and 3D models are generated. Initiated the development of Green bi-propellant-based thrusters as an alternative for chemical propellant for the development of 100 N Thruster. Ignition trials are carried out and further trials are planned.

Deceleration Systems: For validation of the Parachute system, 07 Nos. of Integrated Air Drop Test is planned with simulated Crew module, maintaining the external configuration similar

to flight. Prior to the first IADT, Parachutes are validated with drop test in AN32/IL 76 aircraft and sequence of unfurling operations with load for the Main chute is verified. Development tests of various Mortars (ACS/Drogue/Pilot) and Pyros like Parachute Releaser Unit (PRU), Apex cover separation Pyro thrusters, CM-SM Umbilical pyro bolt, Amplifier Pyro bolt for CM-SM separation system are completed. CM for Trial sortie with Chinook helicopter is realised. The first development test of drogue mortar with drogue chute is completed.

Air Drop Tests: The first Air drop test for Main parachute (ø 25 m) from AN-32 aircraft was successfully completed on October 10, 2021 . Performance of main parachute & Reefing line cutter [RLC] are satisfactory. The second air drop test for the Main parachute (ø 25 m) with 4 T mass from IL-76 aircraft is successfully completed at ADRDE, Agra on November 11, 2021. Performance of main parachute & Reefing line cutter [RLC] is satisfactory.

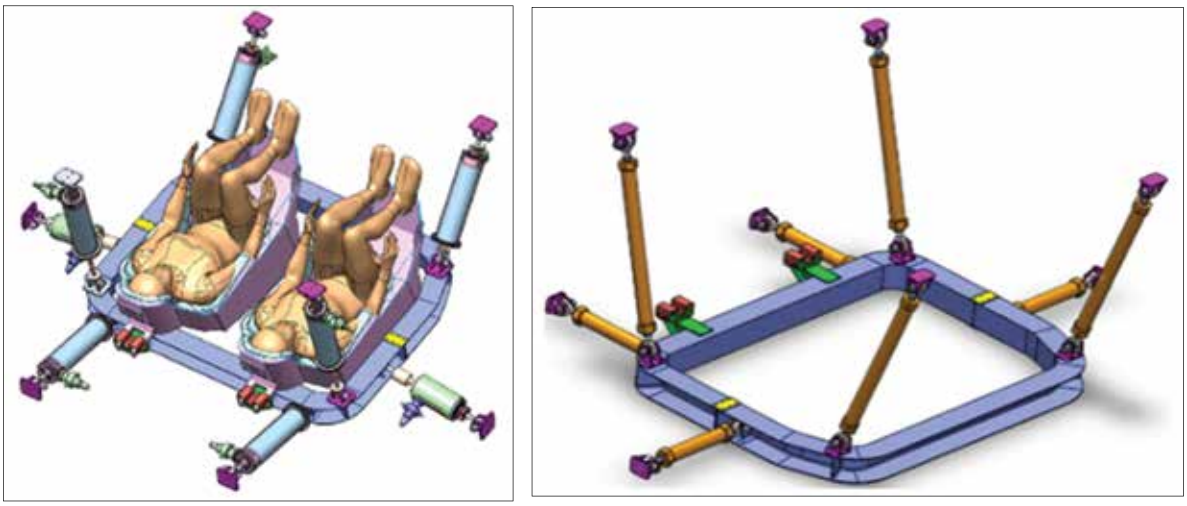


AN32 IL-76 Aircraft drop tests and Main Parachute inflation

View Port: For Procured Viewport, 3 Nos. of Engineering mock-up is received from M/s. GK, Russia and incoming inspections completed. Also, inspection of 12 Nos. of flight viewport has been carried out at Russia.

Crew Seat: Preliminary design of the G1 crew seat assembly is completed. Preliminary structural design of the crew seat assembly for H1 is in progress. Kinematic analysis completed and DRI estimated. Occupant safety analysis is in progress. Crew seat system for manned mission is finalised with required spine angle and attenuator attachment locations inside CM structure. Detailed mass and mass properties for H1 configuration are generated.

2.7 Gaganyaan – Human Space Flight



Crew Seat and attenuation system

Crew Module for Integrated Air Drop test [IADT]:

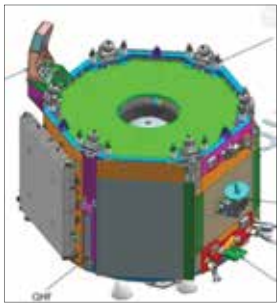
Mechanical: IADT structure design & analysis was completed & presented to DRT. Further design studies are in progress based on DRT suggestions. Action is taken for procurement of all raw materials required for IADT structure.

IADT CM structure

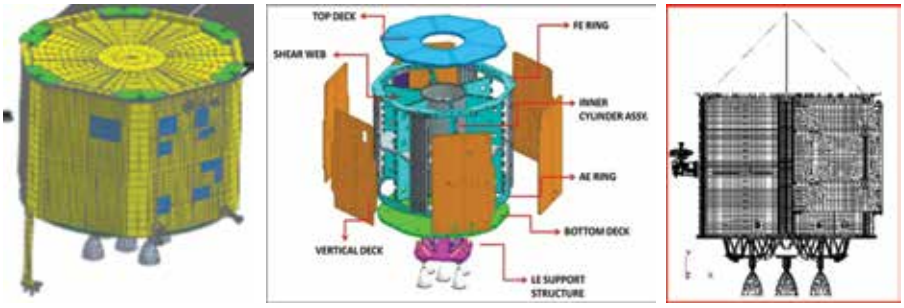
Avionics: The flight Measurement Requirements document was released and the Instrumentation stack configuration worked out. Interface testing of Ka-band altimeter was carried out with RADIC system and ICU. The reconfigured stack of sequencing system for the deceleration system was worked out and is under realisation.

Service Module [SM] for G1 Mission:

Structure: Service Module structure design & analysis, LAM deck structural configurations, cut-outs for RCS & ECLSS has been completed for various configurations and DRT review completed. The RCS configuration is finalized based on detailed studies involving all sub-systems. The ETLS document for TV-D1 has been prepared.



SM Structure with Solar Array Deployment Assembly



Service Module structure configuration

The central cylinder fabrication activities are completed at HAL. Actions are taken for the procurement of all raw material for SM structure fabrication. All required forgings, along with aluminum sheets for G1 have been provided for realisation of rings and panels.

Thermal & TPS: Qualification of Optosil coating on TPS material (MDA & LDCP) is completed. Thermal design & analysis of TV & G1 configuration has been worked out for all mission phases.

Solar panel & SADM: Solar panel & yoke frequency is estimated for stowed & deployed configurations. A detailed Solar panel specification document is prepared. Dual Gimbal antenna [DGA], Solar array deployment mechanism [SADM] & Quadri filer helix [QFH] antenna design & analysis completed. Units are loaded for fabrication. Action has been taken for procurement of all required materials & components for mechanisms.

Deployed view of Orbital Module

AIT: Accommodation studies of all sub-systems in the service module are completed. All Service Module panel layouts were generated & released. ECLSS elements accommodation studies are completed. Design & analysis of all MGSE were completed and actions were taken for its realisation.

Propulsion system: The propulsion layout configuration for SMPS has been finalized. Realisation of 5 Nos. of LAM engine injector components for acceptance hot test identified for G1 mission is completed. Major components like gas bottles, propellant tank, 100 N RCS thruster parts, pressure regulators, check valves, etc., are under fabrication.

2.7 Gaganyaan – Human Space Flight

Service Module System Demonstration Tests for qualification of Propulsion Systems:

Following ground tests for the system under Phase-1 qualification have been successfully completed.

First hot test (Reference test -1A) of Service Module Propulsion System – System Demonstration Model (SMPS-SDM) was successfully completed at the New LAM Test facility at IPRC on August 28, 2021. A hot test with 5 LAM Engine configuration was carried out for a duration of 450 seconds. Test results are satisfactory.

Successfully hot test of SM SDM Module for Gaganyaan Programme

SM SDM test 700 s

The second Hot test– 1B [simulating the nominal de-boost] with 5 Nos. of LAM engine [440 N] and 8 Nos. of control thrusters [100 N] for a test duration of 700 s is successfully completed at IPRC, Mahendragiri on November 8, 2021.

The third sea level Hot Test#1C [600 seconds continuous LAM burn and RCS thrusters in pulse mode during 50 s before and 50 s after LAM, simulating orientation correction as well as simulation of 3 axis attitude stabilisation by RCS during LAM phase of 600 seconds] for a duration of 700s is successfully completed at IPRC, Mahendragiri on December 4, 2021.

The fourth sea level Hot Test# 1D [simulating the LAM engine failure case] with the continuous

firing of 3 Nos. of LAM engine [440 N] and 4 Nos. of control thrusters [100 N] for a test duration of 700 s is successfully completed at IPRC, Mahendragiri on December 13, 2021.

Avionics:

CM Avionics for Test Vehicle:

222 numbers of PCB cards were fabricated and functional testing are completed. QM Battery Vibration and shock test are completed. PDR documents are released. System requirements document (SRD) and functional requirement document reviews (FRD) are completed. Development of 6 DoF software completed and module level validation completed.

Stage processing Package

Mission Computer

DVMs fabricated and tested. Camera-GDHS interface test conducted. SRD and FRD reviews are completed. UHF package ruggedisation completed.

Flight measurement requirements released. Note on the Pyro sequencing command list is released for configuring the CM sequencer. SPS wiring and testing completed. Instrumentation Systems Module T&E in progress. MiniAINS PCB fabricated and system integration in progress. FRD review completed. BALT PCBs fabricated, T&E in progress.

OM Avionics for G1 Mission:

Gaganyaan Avionics configuration finalised. Triple chain configuration with the fail-safe approach adopted. PDR for avionics systems completed. Measurement finalised and communication systems data rates firmed up. Crew communication systems DVM models realised.

Identification of Abort parameters of all critical subsystems in the Orbital Module is in progress. Crew Intervention activities for Gaganyaan mission were identified. Crew Intervention System hardware is under finalisation. Design configurations of DRDO deliverables such as Dosimeter,

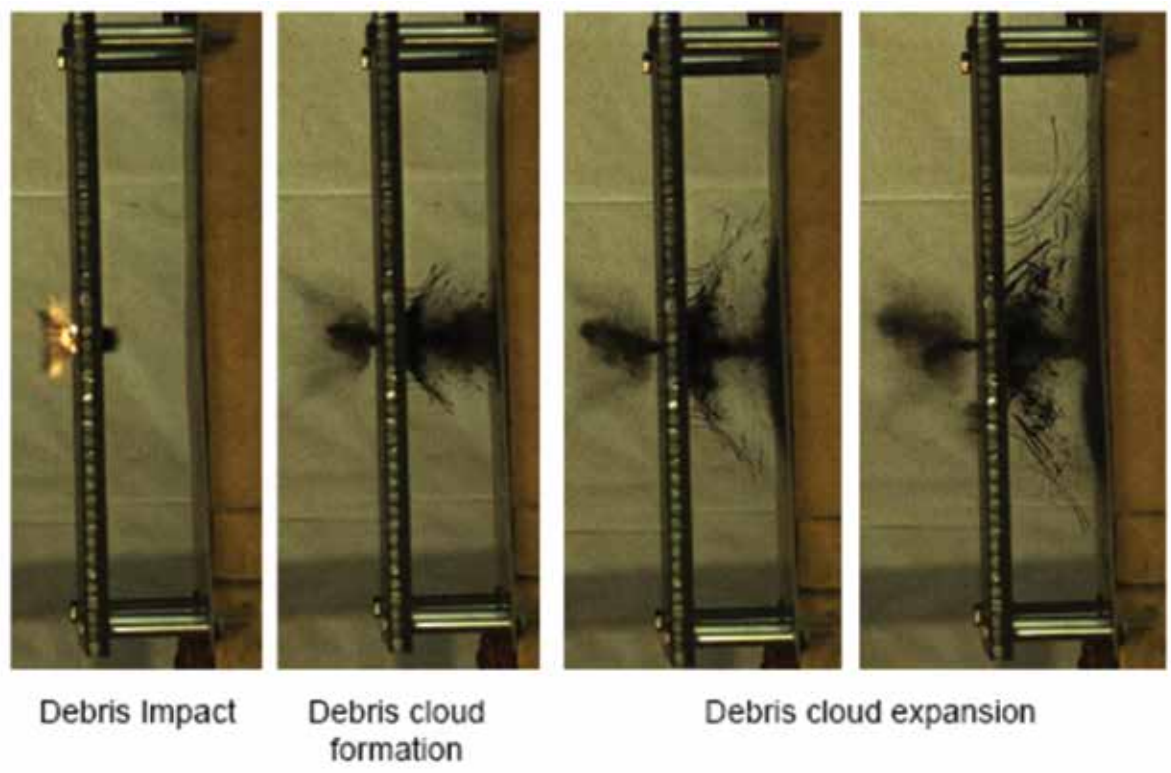
2.7 Gaganyaan – Human Space Flight

Bio vest electronics, food heater were finalised. Proto models of Dosimeter and Food Heater were tested.

Simulator requirements for the Gaganyaan mission have been worked out. Tenders for the fabrication of simulation packages are under process. The updated Frequency coordination document with additional ground stations generated.

MMOD

Assessment of Micro Meteoroid and Orbital Debris (MMOD) that pose a threat to Orbital Module was made and suitable shields were proposed. An MoU was signed with TBRL/DRDO, Chandigarh, for Hyper Velocity Impact (HVI) testing of shield specimens. The methodology of shield design was successfully validated through HVI tests. High-speed photography pictures captured during a test are shown in Figure.



Hyper Velocity Impact Testing of MMOD shield specimen

Human Rating Standards

Human rating certification mechanism and process plan approved by Human Rating

Certification Board (HRCB). A workflow management and document archival software to automate the certification process was developed in-house, successfully implemented across all ISRO centres and made operational and being used. Also, the software is populated with systems/subsystems identified for Gaganyaan mission by respective SDAs. The generic format of Route To Certification Package (RTCP) format is approved by HRCB. RTCP format for systems/subsystems are being tailored from the generic format and such provision is available in GRTC software. The human Rating Requirements document draft was presented by HRCB and referred to the system experts' committee for review. Generation of ISRO'S Guidelines/ Requirements document for manned missions is in progress. In first phase, 25 documents are being prepared and will be released shortly. Probabilistic Risk Analysis(PRA) study teams are constituted in all centres and software for PRA studies already procured and training sessions were organized. Thus, for Gaganyaan all centres are equipped with the capability to carry out PRA for Gaganyaan. Activities to exercise the human rating certification process for G1 mission in monitoring mode are already initiated and in progress.

Human Rated Launch Vehicle [HRLV]

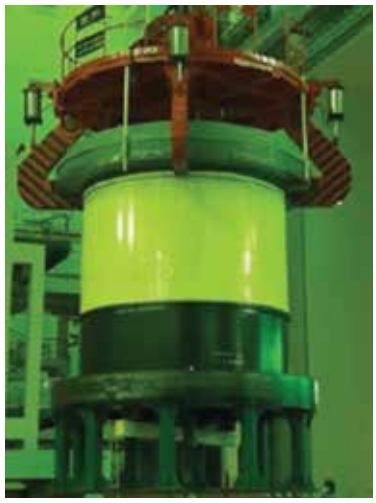
Qualification of Human Rated Launch Vehicle (HRLV) Stages:

Readiness for HS200 Static Testing

Motor Segment realisation completed & delivered to SDSC,SHAR. Motor Segment propellant casting activities completed at SDSC,SHAR.

Middle Segment (MS)

Nozzle End Segment (NES)



Head End Segment (HES)

2.7 Gaganyaan – Human Space Flight

Nozzle H/w & Electromechanical actuator (New design) realisation completed. Trial actuation of Nozzle with newly designed EMA completed.

Electro Mechanical Actuator (EMA)

Nozzle Actuation Trial

L110 - VIKAS Engine (HS-2 Qualification):

Third Long duration test of L110-Vikas Engine (Endurance test for 240 s) successfully completed at IPRC, Mahendragiri. Engine performance parameters & Silica Phenolic Throat system with Ceramic Putty at TRR- Throat interface performance was found normal.

CE20 Engine Hot test (E9 engine):

To demonstrate the repeatability of engine starting with stable combustion, two ignition trial tests for 3.2 seconds conducted satisfactorily followed by successful completion of first Short duration hot test (50 seconds) on December 16, 2021

CE 20 Engine Hot Test

Vikas Engine Hot Test

Readiness for G1 Mission:

HS200 Motors: Realisation of all 6 Nos. of Motor Segment for first unmanned mission completed & delivered & delivered to SDSC,SHAR for casting operations. Hardware realisation of Pyro bolt with dual FLSC for HS200 completed.

L110 Stage: Hardware realisation for first Unmanned mission (G1 mission) nearing completion. Propellant tankages, Interstage structure, realized & delivered to IPRC.

C25 Stage: Hardware realisation for first Unmanned mission (G1 mission) nearing completion. Propellant tankages, Interstage structure realized & delivered. Thrust frame realisation is in an advanced stage.

SM Fairing & Orbital Module Adaptor: DRT-G review completed for SM Fairing. Action initiated for realisation of SM Fairing H/w. DRT-G review for OMA completed. End ring realisation commenced & in the advance stage. Action initiated for realisation through in-house facility & external vendor.

HRLV Avionics: Configuration of IVHM systems, including HRLV and Orbital Module, was worked out. Systems Requirements Document for LVHM is prepared for software design activities.

Crew Escape System [CES]

Qualification of Crew Escape Systems Motors:

Crew Escape System (CES) consists of five different kinds of Solid Rocket Motors. Realisation of CES motors in progress at a different work centre. first batch of Motor hardware for HPM, LPM, HEM & LEM delivered for Static testing. Realisation of CJM hardware for static testing nearing completion.

HPM Static Test: The first High altitude Pitch Motor (HPM ST-01) has been successfully Static tested on July 20, 2021 at RSTD, TERLS. The performance is normal.

LPM Static Test: The first static test of Low Altitude Pitch Motor (LPM ST-01) is successfully completed at RSTD, TERLS on December 29, 2021. The performance is normal.

Processing of HEM & LEM hardware for static testing in progress.

2.7 Gaganyaan – Human Space Flight

Readiness of CES Structures for TV/G1 Flight:

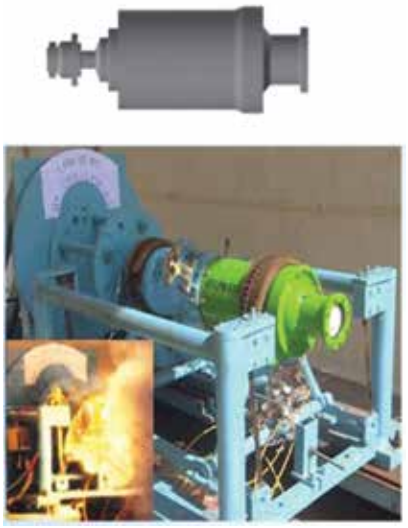
Realisation of first of CES Fore end structures (Ø 8000 mm) is completed through in-house facility of VSSC. Delivery of Subsequent hardware sets from the external work centre commenced. Realisation of Aft End Structures of CES (Ø 4 m) initiated at work centres. 12 Nos. of Grid Fin realized & structural test preparation commenced. DRT-G review for Structural testing of CES structures completed. Action initiated for realisation of the testing fixture. Purchase order for realisation of separation systems of Orbital module placed & delivery commenced.

Static Testing of HPM

Ground Stations and Data Relay Satellites:

TTC network plan for End to end mission, including ascent, on-orbit and descent phase are finalized.

Grid Fin Assy

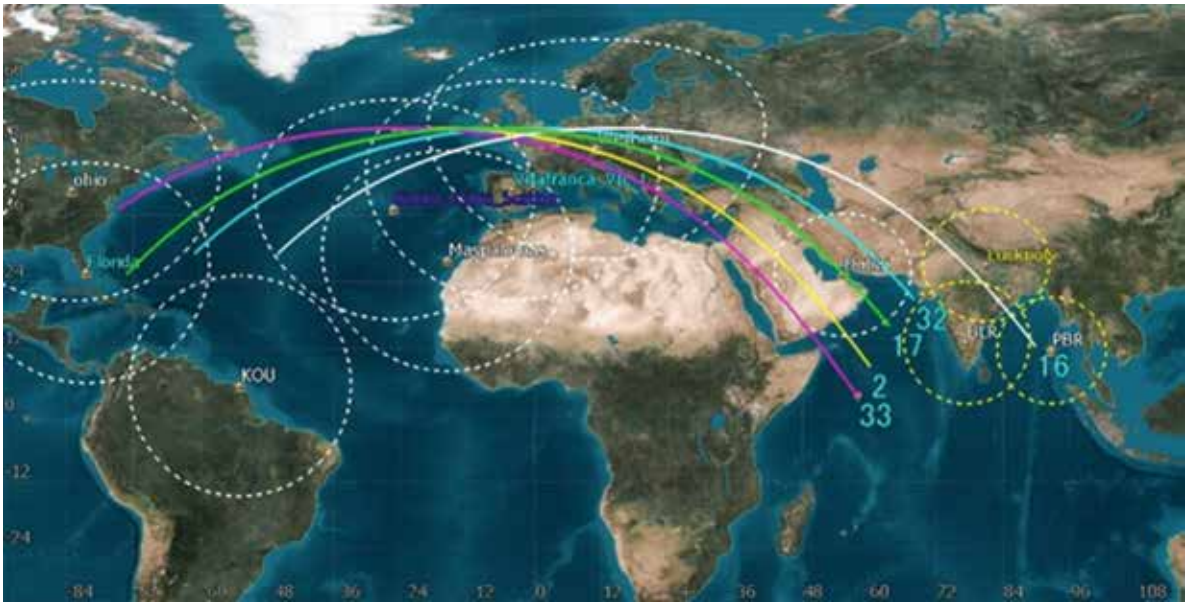


Static Testing of LPM

A ship-borne terminal is planned for TTC coverage in the ascent phase in order to provide better elevation compared to the existing 8° elevation from Port Blair station. IDRSS-2 is planned to be relocated from 148° to 240° in order to provide 100% visibility coverage for the mission.

Proof-of-concept of utilizing Amazon Web Services (AWS) ground stations for Gaganyaan was

demonstrated by testing one of the AWS ground stations for carrying out TTC operations of SARAL satellite. Implementation Arrangement with Australian Space Agency (ASA) has been executed for establishing Transportable TTC Terminal at Cocos island for Ascent phase



support. The Information security features in the onboard as well as ground communication systems of Gaganyaan HRLV, Orbital Module and ground stations were reviewed by Shri A.S. Kiran Kumar, Former Chairman, ISRO.

Readiness of Launch Complex Systems

Second Launch Pad

SVAB: Platform travel range changing completed to accommodate OM activities. Clean tent specifications finalized and fabrication drawings released.

UT: Bubble lift modification commenced and all bought out items were received at the site. Zip line system configuration finalized. Crew Access Arm fabrication completed. White room material testing was carried out and material finalized. Remote Valve Enclosures replacement is completed for L110 and C-25. LTR-G civil construction in progress.

Crew Access Arm Erection at SLP-UT

2.7 Gaganyaan – Human Space Flight

First Launch Pad: Mobile Launch Pedestal (MLP):

Launch Pad interface ring fabrication completed and trial suiting with MLP completed. Secondary access platform fabricated. Handling and tilting tackles fabricated.

Sounding Rocket Complex:

Pad abort test ground fixture fabricated. Modification to existing service tower completed.

Orbital Module Preparation Facility (OMPF):

Civil construction work in progress. Assembly tower design completed and fabrication drawings released.

Gaganyaan Control Facility (GCF):

Civil modification of Old MCC is in progress. Interiors are finalized. Configuration of Display and consoles finalized.

Orbital Module Preparation Facility [OMPF]

Environmental Control & Life Support Systems [ECLSS]

Thermal and Humidity Control System (THCS)

PDR of THCS completed. Realisation of Mock-Up hardware & Demonstration, end-to-end performance assessment and design validation of Non-condensing network of Thermal and Humidity Control System completed.

Cabin Pressure Control System (CPCS)

PDR Completed. Circuit finalized. PDR by SDRC

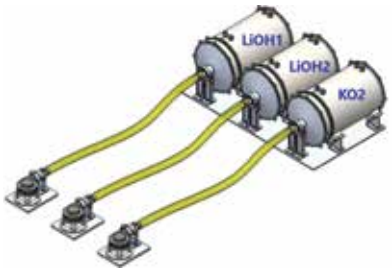
was completed for 13 types out of total 15 types of components at LPSC. Proto- hardware realisation is in progress. Configuration of Cabin Ventilation Unit (CVU) for establishing contact with the atmosphere post touch down completed.

Air Revitalization System (ARS)

ARS configuration finalized. PDR reviewed in DRT. ARS chemicals like LiOH, activated carbon and Potassium superoxide was procured and laboratory level tests carried out at VSSC.

Human Metabolic Simulator (HMS)

Specifications and PDR were presented to DRT-CPCS, DRT-AVN and cleared. Systems engineering and accommodation of LPSC components is completed on crew seat location. Assembly and component drawings generated. HMS electronic circuit indigenisation is in progress.



Configuration of ARS canisters

Systems Engineering:

Accommodation and routing of ECLSS components is completed in SM and ongoing in CM.

HMS Model

ECLSS controller and DAQ:

Controller PDR document is released & Simulator requirement note released. DAQ design in progress.

ECLSS Test Facility:

Approval obtained and location clearance were obtained from the Centre Safety Committee of URSC. Design, estimation and drawings generation is in progress at CEPO.

DRDO Human-centric products:

Functional Demonstration of PERDAA- dosimeter by DL-J, Portable fire suppression system by CFEES completed. Prototype of Medical kit demonstrated by INMAS. Specifications of Emergency Survival Kit (ESK) cleared. A prototype is made by DEBEL. Food menu finalized and feedback from Astronaut trainees was obtained after a tasting session. Total No. of Reviews held- MoU Co-ordination Committee (MCC) - 15, Joint Working Group (JWG) – 3, DRT- Human Centric products- 4, ISRO- DRDO Co-ordination Committee (IDCC) – 1.

2.7 Gaganyaan – Human Space Flight

International Collaboration:

Roscosmos/GK:

Acceptance testing of Space suit, Gloves, Forel suit, Neva, On-board Ventilation unit, Distribution Unit, Portable Ventilation Unit PVU-2M completed at GK.

Facility identified for storage and testing of a Space suit. Indent raised for space suit leak test facility. Items received.

CNES:

Requirement for and design of stowage bags (Food kit, Personal hygiene kit and Medical kit) is provided to CNES. Preliminary drawings received from CNES.

First set of deliverables from CNES- 4 Nos. of Aqua pads received.

Prototype of Portable fire suppression system

Crew Training Simulators [CTS]

Virtual Reality Training Simulator –

Virtual Reality simulator is developed for familiarisation of the Crew Module Inner volume and location of subsystems inside the Crew Module. It also provides training on familiarisation of the console and the display pages during the mission phases. The simulator is realized using a Virtual Reality headset with software programmed in it. Phase 1 simulator supports single Crew training with defined interactions and training in the seat. Phase 2 simulator requirements are being defined to meet multiple crew training, dynamics and micro-gravity situations.

Independent Training Simulator

Independent Training Simulator serves as the primary training platform for practicing Standard Operating Procedures. It consists of a console mounted on a table interfaced with a simulation system for generating the data required to be displayed during the training. Trainor console interfaced with the simulation system allows the trainer to define the test cases during the training. Mission control console with SCHEMACS software provides a platform for the ground Crew to train along with the Onboard team.

Static Mock-Up Simulator

Static Mock-up simulator integrates the Crew Module mock-up structure along with various subsystems inside the Crew module to provide an actual life-size training platform to the

Crew. It has provisions to operate the console along with deployment mechanism, ingress and egress schemes, ECLSS related subsystems, human-centric products and recovery aids. The simulator provides training of multiple crew to train together in the seated condition and includes provisions such as fire simulation etc.

Crew Training

A new Astronaut Training Facility is established in Marathahalli, Bengaluru. Civil, electrical and A/C works for Astronaut Training Facility are completed. Installation of furniture, IT and gymnasium equipment is also completed. Commissioning of the facility is in progress. The facility will cater to classroom training, physical fitness training, Simulator training and Flight suit testing. Chairman ISRO visited the facility on January 03, 2022.

The Astronaut trainees returned from Russia after the completion of generic training. It was followed by aeromedical training, flying practice and psychological evaluation. The mission-specific Indian leg of Crew training was commenced at HSFC /ISRO-HQ on December 7, 2021. The course material was unveiled by Chairman, ISRO/ Secretary DOS in the presence of Wing commander (Rtd.) Rakesh Sharma, Scientific Secretary ISRO, Director HSFC, Director DHSP, Commandant IAM and other dignitaries. The classroom training for December 2021 is completed as per schedule. Physical fitness training was started on January 07, 2022.

Budget:

Based on the programmatic requirements, the BE allocation was Rs.1900.00 Cr. for the FY 2021-22. However, due to -related lockdown, disruptions in supply chain and provision for delivery date extension have resulted in the delay in delivery of hardware/components. Based on RE, the allocation was revised as Rs 1400.00 cr. However, there is no impact with respect to realising the systems for meeting first unmanned mission, since min. of 3 sets is being realized concurrently for meeting the envisaged milestones till G1 Mission. Based on third quarter review, RRE was defined as Rs.1100.0 Cr. for the FY 2021-22. Expenditure as on December 31, 2021 is Rs.730.0 Cr. Plans are in place for achieving the expenditure targets.

2.8 Facilities / Infrastructure

The creation of new infrastructure across ISRO centres, in line with programmatic requirements and long-term goals of organisation, is a major exercise.

Infrastructure at different centres

HSFC: Samanvaya (Integration bay) was inaugurated, The Gaganyaan Astronaut Residential Complex located near ISITE, URSC was inaugurated,

Inauguration of Samanvaya (CM integration bay)

Astronaut Training Facility (ATF)

Interiors of Astronaut Training Facility (ATF)

IPRC

Dynamic Balancing facility II is operational now. Automated cold run test facility II : Instrumentation review is in progress. Structural Test Facility (STF) Design is completed. Semi Cryogenic Fabrication facility was inaugurated.

Semi Cryo Fabrication Facility

500 kWp capacity Solar Power Plants in roof top of various facilities (Under Phase-III)

ISTRAC: Established necessary infrastructures at MOX-1 for carrying out the virtual/remote operation of TTC operations for supporting vehicle Launch missions. Established Gaganyaan Technical Facility (Server Room): GTF Server room facility will host the core of computer and network services for Gaganyaan mission and also shall serve as the control center LAN distribution point for MOX-2 IRS network. Two new Major Civil Works have been realized namely, Construction of 18 m dia antenna supporting structure and facility building (Civil, PH, Electrical and A/c works) at IDSN Campus, Bengaluru, 11 m dia IRCDR antenna supporting structure and facility building (Civil, PH, Electrical and A/c works) at IPF Campus, Port Blair.

LEOS: New facilities installed includes High Accuracy Star Simulator (HASS) setup, Portable Dynamic Multi Star Simulator (DMSS), Optical Grinding Machine, 2-Spindle Type Smoothing and Polishing Machine, CNC Wire Cutting Machine, Thermal Shock Chamber and 2-Axes Motion Simulator.

High Accuracy Star Simulator (HASS)

Dynamic Multi Star Simulator (DMSS)

Wire cut EDM

Thermal shock Chamber

2 Axis rate table

Magnetron Sputtering Cathode & DC Power Supply

New facilities at LEOS

2.8 Facilities / Infrastructure

LPSC

Completed the installation & Commissioning of the Chemical Cleaning Facility at of Integrated Titanium Alloy Tank Production Facility (ITPF)

ECAT Clean Room and Labs: are inaugurated. The Class 10000 clean room is equipped with pneumatic test consoles, vacuum drying ovens, microscopes, spring testing machines, profile projectors etc.

Established the Mechanised chemical treatment facility (MCTF) at LPSC, Bengaluru

NRSC: Integrated Multi-mission Ground Segment for Earth Observation Satellites (IMGEOS) was augmented with Tier-1 storage capacity by 500 TB using SSDs, Tier-2 storage capacity to 3.2 PB using NL-SAS disks. Tier-3 is tape-based with 6500 Slots 36 PB Capacity using 16xLTO-5 and 16xLTO-7 drives.

SAC: Compact Antenna Test Range (CATR) facility was completely rejuvenated and its original quiet zone performance (quiet zone of 5.5 m x 5 m x 8 m) was achieved. The performance was validated using an indigenously developed quiet zone probing system and standard reference antennas.

CATR

Other facilities established include: New LTCC Sintering furnace, 1 mil Wedge/ball bonder, Wafer Level Packaging Technology, End to end Infrastructure establishment for design, fabrication, processing, assembly, integration & testing of TWTAs, Vapour phase reflow system, Thermal Vacuum chambers, Pendulum Hammer Shock Testing Facility.

Installation, Commissioning & Operationalisation of 6 nos. of Thermal Vacuum chambers @ New Bopal Campus

Wafer Level Packaging Technology

NE-SAC foundation stone laid for the Multi-purpose Convention Centre cum Space Exhibition facility.

SDSC SHAR

Augmentation of Solid Motors Production Facilities Project (ASMP)

Out of 29 process facilities, Civil works were completed for 12 buildings and works are in progress for the remaining buildings.

PSLV Integration Facilities (PIF): PIF Integration Building all 15 floors concreting works completed. MLP Track (1440 m) completed. Service Building structural works completed and finishing works in progress.

2.8 Facilities / Infrastructure

Gaganyaan Launch Complex & Recovery Systems (GLCRS) – Gaganyaan Launch Complex & Recovery Systems project is planned at SDSC SHAR towards enabling Human Space Missions from Second Launch Pad (SLP) and realisation of associated Crew facilities.

URSC

- Expansion of Mission Analysis Centre (MAC) Facility: MAC-1 &MAC-2 to support dual launch LEOP operations from URSC is completed. All the necessary infrastructure in line with Satellite Control Centre are being implemented at the MAC facility.

- Working Fluid Charging Facility is established at Advanced Heat Pipe Technology Development Facility, ISITE Campus. This state-of-the-art automated R&D facility facilitates charging working fluids like Ammonia, Acetone, Ethane etc. in miniaturized heat pipes, loop heat pipes, Mechanical Pumped Fluid Loops (MPFL) and future advanced two-phased thermal devices.

Inauguration of Working Fluid Charging Facility by Director, URSC on 29.9.2021 at advanced heat pipe technology development facility, ISITE

A new sophisticated spacecraft transportation trailer with a prime mover with a payload-carrying capacity of 55 T is realized to facilitate Satellite/Payload Panels/Subsystem movements smoothly across ISRO Centres.

Establishment of 20 T Shaker Facility, extension to URSC Clean room and large space simulation Chamber building is in progress at URSC main campus.

VSSC

- Space Pyros Augmented Realisation Complex (SPARC): Six facility/buildings of phase-1 are in the advanced stage of construction. Construction of 5 facilities/buildings of phase-2 initiated. Equipment, furniture and DG set procurement in progress.

Trisonic Wind Tunnel Project: 6 nos. of Air storage vessels are fabricated, radiographed and successfully hydrostatically tested at site. Fabrication of the settling chamber is completed, and integration is nearing completion. Fabrication, machining and hydrostatic test of Pressure Regulating Valve (PRV) are completed and the component is received at the site after functional tests. Fabrication & machining of the 4 Nos. of support structures, 2 Nos. of jack beams, 38 Nos. of jack station, 2 Nos. of side plate and 2 Nos. of the flexible plate of Flexible Nozzle are completed. 2 centrifugal compressors and 2 dryers are erected. Major components are received at the site and site integration is under progress for the first blow down.

High capacity UFAP facility: Fluid Energy Mill, Air Handling units and Characterisation system completed.

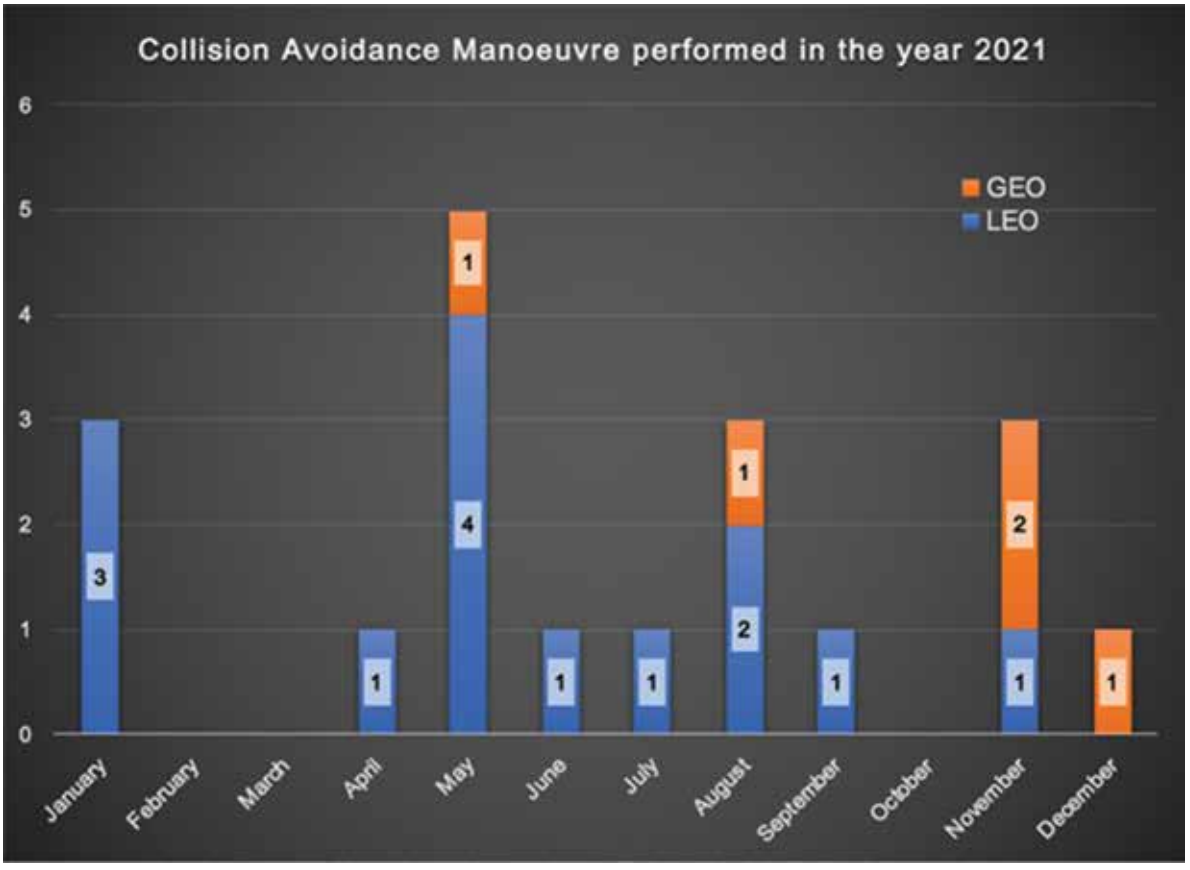
Production Hub for chemicals and polymeric products, fuel cell lab, VRC main building augmentation for technical activities – phase 1, robotics and mechanisms lab are getting ready.

New facilities commissioned are 3 & 5 axis CNC machines, 1M Gantry CNC filament winding machine, CNC fiber placement system, CNC vertical turning &machining centre, automated pressure testing system, automated 450 kV digital radiographic system, 3 m class hot air oven, 4 m class filament winding machine with a robotic arm, dry room facilities for advanced energy & power systems, new AP process facility at APEP, NR for ETA, VLCC, static test facility at Walchand new sounding rocket assembly building, foams and resins facility, Evobeam 6 kW EBW machine, portable pneumatic test station in test & evaluation facility, cryostat facility, remote online inspection facility, sounding rocket assembly building. Added Photonic Doppler Velocitymeter (PDV) to ADRL.

2.9 Space Situational Awareness and Management

Directorate of Space Situational Awareness and Management (DSSAM)

The Directorate of Space Situational Awareness and Management (DSSAM) is responsible for formulating and executing strategies for Space Situational Awareness and Management of Indian space assets. The office ensures necessary policy interventions to comply with the national and international mitigation guidelines & STM principles to establish an operational mechanism to manage ISRO's space assets through well-planned interfaces across various centres.

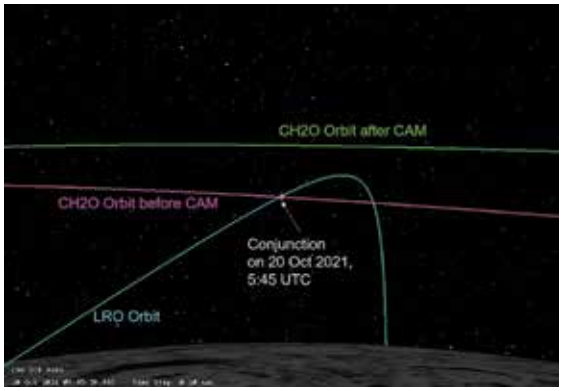


Collision Avoidance Manoeuvre performed in the year 2021

4. Project NETRA (Network for Space Objects Tracking and Analysis):

As part of global efforts to secure space resources for future generations and to protect Indian space assets from an accidental collision with space debris, DOS approved 'Project NETRA', an initiative to acquire indigenous capabilities to detect, identify, track and catalog space objects. Under Project NETRA, activities for setting up of Control Centre, Multi-Object Tracking Radar and Optical Telescope for space debris observation are in progress.

A critically close approach situation between Chandrayaan-2 Orbiter and NASA's Lunar Reconnaissance Orbiter, which was expected to occur on 20 Oct 2021, was effectively mitigated through an evasive manoeuvre of Chandrayaan-2 on 18 Oct 2021. The decision to perform the manoeuvre was taken jointly by NASA and ISRO as close approach distance was consistently found to be within the critical alarm threshold over several days.



4.1. Control Centre:

DSSAM commenced its activities from ISRO SSA Control Centre at Peenya on January, 18, 2021. Core SSA operations related to safeguarding Indian space assets like conjunction analysis for collision risk mitigation have started in the SSA Control Centre after deployment of the relevant software and hardware elements. A preliminary version of observational data processing and space objects' orbit determination, data correlation and object identification has also been deployed. Further deployment of computational and networking infrastructure is in progress. The control centre is envisaged to function as a hub of all SSA activities within India.

4.2. Radar:

The Multi-Object Tracking Phased Array Radar under the NETRA project, capable of tracking objects of size 10 cm or larger at a range of 2500 km, shall be established in the northeastern region of India. The activities related to finalising the land and realisation of Radar has been initiated.

2.9 Space Situational Awareness and Management

4.3. Optical Telescope:

The Optical Telescope under the NETRA project, capable of tracking objects of size 40 cm or larger at GEO, shall be established on Mt.Saraswati, Hanle, Ladakh, in collaboration with the Indian Institute of Astrophysics. The activities for infrastructure development of the optical telescope like topographical survey, site leveling, design & laying of access roads and geotechnical investigations are under progress.

Collaborations

- An Implementation Agreement was signed with the Indian Institute of Astrophysics to develop new infrastructure and to upgrade & utilize existing infrastructure in Hanle, Ladakh for the establishment of the optical telescope under NETRA project.
- A Non-Disclosure Agreement was signed with the State Space Agency of Ukraine to acquire information on the observational facilities in Ukraine in order to assess the feasibility of utilizing the space objects tracking data from the facilities in the Indian SSA network.
- A two-day technical meet on SSA was jointly organised by ISRO and CNES with participation from engineers from ISRO (ISTRAC, MCF, VSSC, SDSC, URSC) and CNES. The presentations covered topics including space object observation, collision avoidance methodologies and operational nuances, orbital debris environmental modelling, re-entry analysis, future challenges for SSA etc. A delegation comprising members from DSSAM, ISTRAC and VSSC attended the meet at Toulouse. In addition, prospective areas of collaboration on SSA were identified after deliberations with officials from Airbus and CNES at Toulouse, ShareMySpace, Paris Peace Forum and Thales Alenia Space at Paris.
- ISRO was represented through active participation in the deliberations of the steering group and the working groups in the annual Inter-Agency Space Debris Coordination Committee meeting held in April 2021 in virtual mode. The annual status of space debris activities in ISRO was compiled and presented in all working groups. The first experience of operating in the presence of the Starlink constellation and future concerns was presented in WG4, which was well-received by the members.
- Re-entry prediction for IADC's annual re-entry campaign of Starlink -26 was carried out. ISRO proposed, to the steering group, to conduct an ad-hoc campaign for the core stage of Long March 5. The proposal was endorsed by all IADC members, including China.
- Inputs on the status of implementation of LTS (Long Term sustainability) guidelines were provided to the LTS working group. A note on the ISRO case study on post-mission disposal of operational satellites was prepared in collaboration with OIIC, which was published on the UN website after MEA clearance.

2.10 Quality Management

Space is unforgiving and space technology calls for the most meticulous compliance to quality requirements. Rugged quality practices are in vogue at ISRO/DOS towards ensuring that no defect goes unnoticed. It is the combination of the strengths of quality practices and the multi-tier review mechanism that is demonstrated through the success of missions. 2021 was characterized by rapid progress in several developmental missions of ISRO, including Gaganyaan mission, and the Quality and Reliability teams across the Centres/Units carried forward the baton of meticulous care and attention in all of ISRO's endeavors. The conviction and commitment of DOS to quality is also evident from the fact that one of the major responsibilities of the newly established Technical Directorate of the Indian Space Promotion and Authorization Centre (INSPACe) is to specifically focus on the quality aspects as well as to generate quality and reliability standards for commercial space activities. The famous saying "Quality is not an act, it is a habit" was completely in action with the quality teams of ISRO contributing immensely to the development and testing of ventilators and oxygen concentrators towards meeting the emergency needs of the nation.

A deep dive into a few salient and silent achievements of the quality teams spread across DOS/ISRO Centres/Units are provided in this section.

Sustaining the Culture of Quality

Quality is the cornerstone for all verticals of ISRO, namely space applications, satellites, ground support systems and launch vehicles. All the aspects of design, development, realisation, testing and certification are carried out with a specific eye on quality. The quality teams continued to keep a close watch on the quality of systems realized at the internal and external work-centres (Industry partners from the public and private sector) of ISRO/DOS. Core responsibilities of rigorous testing, analysis, qualification, acceptance, certification, audits, reviews, etc., along with compliance to quality manuals, plans and procedures, checklists etc. continue to be the mainstay for the quality teams. As is the practice every year, Quality Day was observed across five major centres of ISRO towards revitalizing and sustaining ISRO's homegrown culture of quality. The first set of ISRO Quality Awards was presented to six meritorious quality engineers and ten technicians/technical assistants as a mark of ISRO's recognition to the entire quality community.

Directorate of Safety, Reliability and Quality (DSRQ)

In addition to the quality control and quality assurance teams deployed across DOS/ISRO Centres/Units and external work-centres, a completely independent and dedicated directorate-DSRQ, based at ISRO Headquarters, works towards identifying and addressing

2.10 Quality Management

safety, occupational health, environment, system reliability and quality and coordinate to establish uniform safety and quality standards across ISRO Centres/Units/external work-centres. The is responsible for enabling periodic audits and formulating policies, guidelines, Crisis Management Plans and encouragement schemes for systematic improvements in various areas and implementing the same. Also responsible for interacting with statutory government authorities to address safety and industrial security protocols, develop programmes like Zero Defect Delivery Programme (Zee-DP) and Absolute Quality Programme (AQP) to ensure improvement in quality. DSRQ shoulders the responsibility of sharing of best practices amongst ISRO Centres and Units through an inter-centre forum named Integrated Product Assurance Board (IPAB).

ISRO Technical Standards (ITecS)

DOS has taken up the initiative of documenting the rich heritage and knowledge base of Space systems acquired over the last five decades. This institutional memory is being preserved for posterity in the form of ISRO Technical Standards (ITecS). ISRO's endeavors towards safeguarding the indigenous know-how in the form of ISRO Technical Standards continued this year too.

Four ITecS documents have already been released earlier this year. And this year, the ISRO Technical Standard on "Specifications for Silica Fabric including process plan and acceptance protocol","Specifications for Rayon-based Carbon fabric including process plan and acceptance protocol", "Environmental Testing for Launch Vehicle Components and Sub-assemblies", and "Handbook of On-Board EE (Electrical and Electronics) Systems Design Rules" was generated and ready for publication.

Other salient achievements of the quality teams – Developmental missions

Quality teams significantly contributed towards the testing of various systems for the challenging Gaganyaan mission. The role of the quality teams in the testing of human-rated L110 Vikas engine, cryogenic stage, crew escape system motors, and service module propulsion system has been significant. Enormous progress was also made with respect to the qualification of various systems for Small Satellite Launch Vehicle (SSLV), Test Vehicle Project (TVP), Re-usable Launch Vehicle (RLV), Semi-cryogenic engine/stage, etc. Quality teams also took up several technology development programmes for enhancing the reliability of space systems.

The development, testing, acceptance and qualification of S-Band Synthetic Aperture Radar (SAR) for the prestigious NASA-ISRO Synthetic Aperture Radar (NISAR) project, various tests

and studies for ADITYA-L1 and XpoSat, as well as a series of improvements and tests for the development of the prestigious Chandrayaan-3 mission were also taken up by the quality teams.

As a part of external station support services for the science missions and human space flight mission, DSRQ has taken a lead role in coordinating with different ISRO work-centres in ensuring the quality processes are adhered and a QA Requirements document for these missions for the external ground network of stations was brought out. This document addresses the QA requirements along with the route to certification criteria towards probabilistic risk assessment parameters.

2.11 Occupational Health & Safety

Space program necessitates critical operations which are hazardous in nature and requires extreme precautions to prevent an unintended incident or an accident. A minor safety lapse is enough to jeopardise the programme or delay a vital schedule of the programme. ISRO has well defined Occupational Health and Safety management system in place and the primary objective is to control the hazards at the system level by eliminating failure modes. Occupational Health and Safety management system at ISRO is a planned, disciplined and systematic approach to identify, analyse, and control / eliminate hazards to protect humans, machines and material.

In order to achieve the highest occupational health and safety standards in every operation of ISRO/DOS and to take care of statutory obligations with external agencies, a dedicated team of Occupational Health and Safety experts are in position at ISRO Centres/Units & Directorate of Safety, Reliability and Quality (DSRQ), ISRO HQ.

Occupational Health and Safety activity Highlights

The space programme continued to be free from any major incidents during this year as well. The launch campaigns of PSLV-C51/ Amazonia with 18 satellites and GSLV-F10/EOS-03 missions were completed without any safety-related non-conformance and anomalies. Alike previous launches, well-established safety procedures, safety standards and emergency preparedness plan were implemented to prevent unforeseen incidence. Safety surveillances were available round the clock during the launch campaign activities. Activities involving production and transportation of solid propellants, earth storable propellants, cryogenic propellants, rocket motors & pyrotechnic materials etc; and assembly & integration of rocket stages and satellites and high-pressure gas servicing at launchpad were carried out under the full-time participation of safety team.

The most significant achievement from a safety perspective is the successful and safe completion of cold flow tests of eco-friendly Semi-cryogenic Engine Thrust Chamber Nozzle Assembly (AR5), Qualification of 58 N engine for Chandrayaan 3 mission, System Demonstration Model (SDM) for Gaganyaan mission, Proof pressure test of PS4 propellant tank, L110 N propellant tank, C32 LH2 propellant tank and CUS LOX propellant tank at IPRC and Commissioning of world-class Liquid Incinerator Facility for Effluent treatment (LIFE) at VSSC.

Safety surveillance ensured during fabrication, integration, Thermovac test, vibration tests and pressure hold test of Chandrayan-3 propulsion system, EOS-03 , IRNSS- 1J, RISAT- 1A,

Scat 3 satellites. Safety review of radiation sources for various spacecraft was also completed without any waivers.

Safety committees at various ISRO/DOS centres reviewed and cleared locations for the construction and commissioning of new facilities. Imparted safety inductions to all personnel joining ISRO and specific safety awareness was given on work-related hazards. The training was provided on fire fighting and general safety to all employees in ISRO. Safety promotional activities have been continued through the celebration of National safety day, Fire service day, World environment day by issuing posters and conducting safety seminars.

2.12 International Cooperation

ISRO continues to pursue its successful cooperation with bilateral and multilateral relations with space agencies of other nations and multilateral organisations through carrying out joint activities of mutual interest; sharing expertise in the applications of space technology, organising international events in India and participating in international events. The scope of international cooperation is becoming wider and diverse, in tune with ISRO's enhanced capabilities.

Till date, ISRO/DOS and India have signed space cooperative documents with space agencies of 60 countries and 5 multinational bodies (European Centre for Medium Range Weather Forecasts – ECMWF; European Commission – EC, European Organisation for the Exploitation of Meteorological Satellites - EUMETSAT, European Space Agency – ESA; and South Asian Association for Regional Cooperation – SAARC).

In order to intensify the existing space relations and also to establish new relations with other nations in the peaceful uses of outer space, 11 cooperative documents with foreign entities were signed during this period.

India and USA intensified their space cooperation and carried out many activities during this period. Significant progress has been made in the joint realisation of the microwave remote sensing satellite mission, 'NASA-ISRO Synthetic Aperture Radar (NISAR)' by shipping the ISRO's S-band SAR payload and other hardware's to JPL for conducting various joint S-band &. L-band payload integration tests. The ISRO's S & L-band Airborne SAR (ASAR) repeat flight campaigns were conducted in 2021. ISRO-NASA Joint Working Group on Human Spaceflight Programme (HSP) had a meeting to explore collaboration opportunities. Under the ISRO-NOAA cooperation, ISRO is receiving the NOAA's commercially licensed GNSS radio occultation data and discussions are progressing well under the new Heliophysics Working Group.

India-Russia space cooperation made significant progress in this period, mainly in the field of the Human Spaceflight Programme. The 04 Indian astronaut candidates have successfully completed the general astronaut training at Gagarin Cosmonaut Training Centre, Russia. The discussion has also progressed with respect to the establishment of the NavIC reference station in Russia and GLONASS reference station in India. In connection with the enhanced cooperation, an India – Russia technology protection agreement was signed in December 2021. As a new initiative under India-Russia space cooperation, ISRO and the Russian Academy of Sciences (RAS) have started exploring cooperation in space research.

Space cooperation with France has expanded beyond Earth observation to include newer areas, including human spaceflight and space situational awareness (SSA). ISRO – CNES joint

workshop on SSA was conducted at Toulouse with ISRO officials participating in person. The technical discussion on establishing an ISRO ground station at French Guyana is also progressing.

Signing of IA between ISRO and CNES for supply and services for Gaganyaan programme

India-Japan space cooperation is currently focusing on lunar exploration, satellite navigation and earth observation. ISRO and JAXA are specifically working on: completing the phase-A study of the joint Lunar polar exploration mission; finalizing the instruments to be accommodated in lander and rover; sharing earth observation data for agro-meteorology products and rice crop monitoring; and establishing ISRO's NavIC reference station in Japan.

ISRO and European Space Agency (ESA) have enhanced their cooperation from earth observation and space exploration domains to other areas. Apart from signing required documents for network and operations cross-support, mainly for ISRO's Chandrayaan-3 and Aditya-L1 missions, both sides have agreed to conduct calibration testing of NavIC - Galileo timing receiver at ESA premises to estimate the time offset between NavIC and Galileo. All these activities are being pursued under ISRO-ESA Framework Agreement of 2002.

Under India's BRICS Chairship in 2021, ISRO organised a meeting of Heads of Space Agencies of Brazil, Russia, India, China and South Africa in virtual mode on August 18, 2021, during

2.12 International Cooperation

which 'Agreement among the BRICS space agencies on cooperation on BRICS remote sensing satellite constellation' was signed.

BRICS Space Agency Heads signing Agreement on Remote Sensing Constellation

As announced during the visit of the Honorable Prime Minister of India to Bhutan in August 2019, India and Bhutan are working towards jointly realising a small satellite. With the signing of IA for the joint realisation of the satellite, Bhutan engineers are currently in India as part of the Phase-2 training and design & validation of the secondary payload of the satellite.

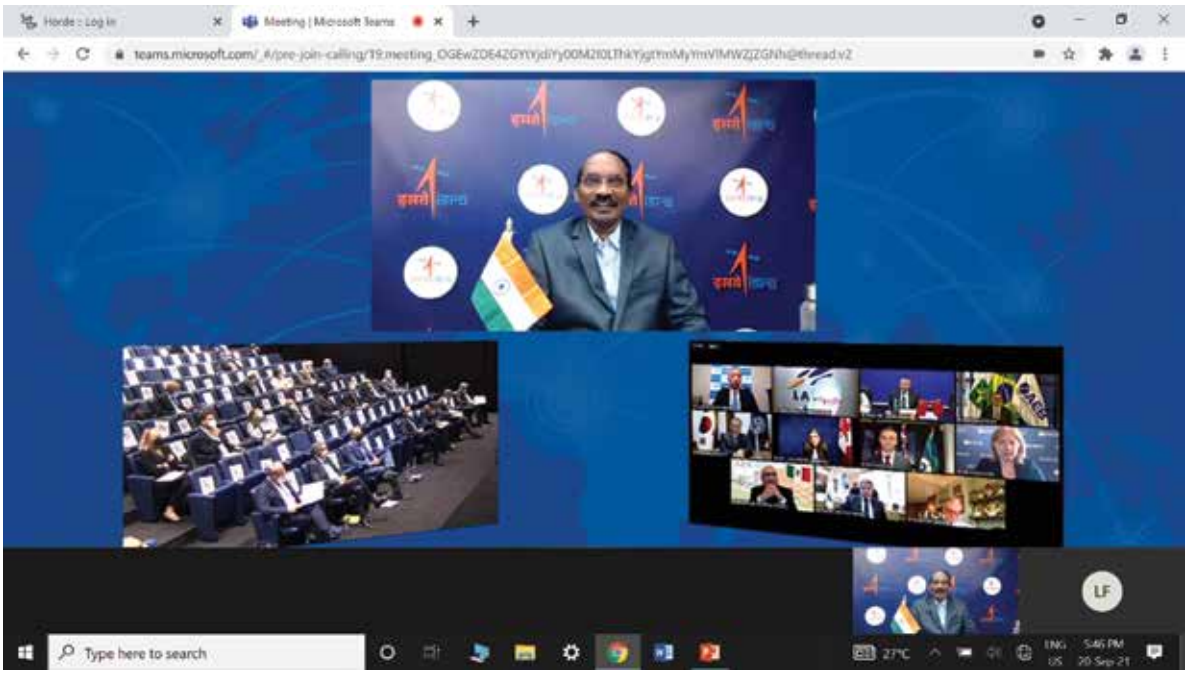
As part of India-Australia space cooperation, discussions are progressing towards establishing the ISRO's transportable ground station at Australia's Cocos-Keeling island (CKI) for Gaganyaan mission.

ISRO and Israel Space Agency (ISA) have a kick-off meeting for cooperation in flying ISA's Electric Propulsion System (EPS) in ISRO's small satellite.

Thematic workshops to explore cooperation opportunities were conducted with Netherlands entities (on Air Quality monitoring) and Morocco officials (on Earth Observation applications).

ISRO is working on a programme to support the Association of SouthEast Asian Nations (ASEAN) to receive and process data from Indian remote sensing satellites and also to provide training in space science, technology and applications. Under this, a new ground station will be established by ISRO in Vietnam and the existing Indonesian station will be augmented. A joint working group with members from ISRO and Vietnam entities is formed for monitoring the civil construction works and for reviewing the Ground station realisation activities.

Chairman, ISRO/ Secretary, DOS had virtual meetings with his counterparts from Italy, Japan, France, and Israel in addition to the various bilateral meetings, in person, on the sidelines of IAC at Dubai. Chairman ISRO/ Secretary DOS also participated in (i) Second G20 Space Economy Leaders meeting; (ii) Heads of Agency Plenary at the International Astronautical Congress at Dubai (iii) Sydney Dialogue event on 'Contested Space: Collaborating in the New Golden Age of Space'; (iv) ASCEND event on "Accelerating Space Exploration through Global Cooperation" organized by American Institute of Aeronautics and Astronautics (AIAA); and (v) Space Leaders' Roundtable panel at Asia Pacific Regional Space Agency Forum (APRSAF).



Meeting of G20 Space Leade

In the field of capacity building, ISRO continues to share its facilities expertise in the application of space science and technology by conducting short-term and long-term courses through the Indian Institute of Remote Sensing (IIRS) and the United Nations (UN) affiliated Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) at Dehradun. As of now, there are more than 3420 beneficiaries from 109 countries.

ISRO continues to play an active role in the deliberation of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) and ISRO delegation participated in-person and in virtual mode at the 58th session of Science and Technology Sub-Committee

2.12 International Cooperation

(STSC), 60th session of Legal Sub-Committee (LSC) and in 64th session of UNCOPUOS. Shri Umamaheswaran. R, Distinguished Scientist & Scientific Secretary ISRO, was elected as the Chair of the STSC Working group on Long Term Sustainability of outer space activities (WG-LTS) at the 58th Session of STSC for a five-year tenure.

Many dignitaries, including French Minister for Foreign Affairs, Colombian Vice Minister for Science, Technology & Innovation and Belgium Ambassador, visited ISRO facilities.

ISRO also actively participated in the meetings of prominent multilateral fora including Asia-Pacific Regional Space Agency Forum (APRSAF), International Astronautical Federation (IAF), International Academy of Astronautics (IAA), International Institute of Space Law (IISL), Committee on Earth Observation Satellites (CEOS), Intersputnik International organisation of Space Communication (INTERSPUTNIK), Coordination Group on Meteorological Satellites (CGMS), International Committee for Global Navigation Satellite Systems (ICG), Committee on Space Research (COSPAR), International Space Exploration Coordination Group (ISECG), Inter-Agency Space Debris Coordination Committee (IADC) and Space for Climate Observatory (SCO).

2.13 Space Commerce

New Space India Limited (NSIL)

NSIL got incorporated on March 6, 2019, as a wholly-owned Government of India Undertaking/ Central Public Sector Enterprise (CPSE), under the administrative control of DOS, to enable Indian Industries to scale up high-technology manufacturing base for space programme and to commercially exploit the products and services emanating from the Indian Space Programme for meeting the domestic and global customer needs. NSIL has been categorized as a Schedule 'A' CPSE by Dept. of Public Enterprises (DPE) on Feb 6, 2020.

During June 2020, as part of Space Reforms "Unlocking India's potential in the space sector", an initiative by the Government of India, NSIL got mandated to undertake End to End Commercial Space Activities related to Satellites and Launch Vehicle Systems. NSIL has the primary mandate of undertaking space missions on a "Demand-Driven" based model as compared to the "Supply Driven" model that existed earlier.

The Enhanced Mandate of NSIL is as indicated below:

1) Owning satellites for Earth Observation and Communication applications and providing space-based services
2) Building satellites and launching them as per demand
3) Providing Launch Services for satellite belonging to the customer
4) Building Launch Vehicles through Indian Industry and launch as per satellite customer requirement
5) Providing Space-based Services on a commercial basis
6) Satellite building through Indian Industry
7) Mission Support Services to National and International Customers
8) Technology Transfer to Indian Industry

Significant Achievement during the Year

One of the major achievements during the year was the launch of Amazonia-1 satellite of INPE, Brazil, onboard PSLV-C51 flight on February 28, 2021. PSLV-C51/ Amazonia-1 Mission was the First Dedicated Commercial Launch Service Mission of NSIL.

Business Accomplishments

NSIL has made a good stride in all its major business activities. Major highlights of business accomplishments are as under:

2.13 Space Commerce

1. Owning and operating the satellites on Demand Driven model

- NSIL has taken up the activity for realizing a Ku-band Communication Satellite for an Indian DTH operator, including its launch and providing space-based services on an end-to-end basis. NSIL is building this satellite through ISRO, getting it launched by a foreign launch service provider and will be owning and operating the satellite. This will be the first Demand Driven mission of NSIL.
- In addition, discussions are also underway for building two more communication satellites for Indian customers, namely, Ku-band Communication Satellite for a DTH operator and HTS Communication Satellite for Broadband communication needs.

2. Launch Services for international customer satellites

- As of date, NSIL has launched a total of 46 international customer satellites under commercial arrangements.
- NSIL has successfully secured and signed Four PSLV Dedicated Launch Service Agreement for International satellite Customers for launch during 2022-23.

3. PSLV production through Indian Industry

- As part of its mandate, NSIL will be end-to-end building launch vehicles through Indian Industry. In this regard, realisation of 5 no. of Polar Satellite Launch Vehicle (PSLV) through "Indian Industry" has been taken up. NSIL released the Request for Proposal (RFP) to Indian Industry partners for the same. Proposals received from various Indian industry partners are under Techno-commercial evaluation at NSIL.

4. SATCOM services

- NSIL, as part of SATCOM Services, is provisioning transponders in C, Ext. C, Ku- and Ka-band on-board INSAT/ GSAT satellites for meeting various applications needs like DTH, VSAT, TV, DSNG. In addition, NSIL is also provisioning transponder capacity from foreign satellites to Indian users on a back-to-back arrangement basis. These transponder capacities are provisioned to various users from the private/ public/ Government sector under 150+ Agreements/ MOUs.
- NSIL is in the process of commercializing HTS capacity on various INSAT/GSAT satellites, namely GSAT-11, GSAT-19, and GSAT-29 to the Private/ Public Sector.

5. Mission Support Services

- NSIL is closely working with global ground station operators and satellite owners to provide Mission Support Services for Satellites and Launch vehicle tracking.

- NSIL has provided Launch and Early Orbit Phase (LEOP) support to Amazonia-1 Mission of INPE, Brazil, during Feb-Mar 2021. NSIL has also provided Launch Vehicle Tracking Support for an International Customer's Launch Vehicle during Jun-Jul 2021 and LEOP Support for an Indian Customer during Feb-Mar 2021.

6. Technology Transfer/ spin-off

- NSIL has been mandated to transfer the Technologies emanating from R & D activities of ISRO/DOS Centers/ Units to Indian Industries for the larger benefit of stakeholders in the ecosystem. During the FY 2020-21, NSIL has signed 15 Technology Transfer Agreements for transferring 8 ISRO developed Technologies to Indian Industry.
- NSIL, by utilizing the Technical Services of Semi-Conductor Laboratory (SCL) of DOS, is provisioning ASICs, Systems/ Sub-systems to its customers.

Financial Summary

During the FY 2020-21, Company has achieved revenue of ₹ 444.34 Cr. and made a Profit after Tax of ₹ 121.84 Cr.

Resource Management

3.1 Budget

Budget at a Glance

(₹ in Crores)

Sl No.	Particular	BE 2021-22	RE 2021-22	BE 2022-23
1	Establishment Expenditure	186.47	205.99	259.00
2	Space Technology	10250.16	9015.20	10534.50
3	Space Applications	1476.85	1322.24	1482.80
4	Space Sciences	274.50	211.80	206.11
5	INSAT Satellite Systems	329.61	389.68	418.59
6	Other Central Sector Expenditure	1431.50	1497.08	799.00
	Total	₹ 13,949.09	₹ 12,642.00	₹ 13,700.00

3.2 Human Resource

The total approved sanctioned strength of the Department as on March 1, 2021 is 20737, out of which 19247 is sanctioned strength of ISRO Centres/Units and 1490 is sanctioned strength of autonomous units of DOS. The Scientific & technical manpower is about 75% of the overall manpower and administrative manpower is 25%.

The existing welfare measures such as housing, medical, canteen, schooling for children, etc. are extended to the employees of ISRO under various approved institutional schemes. Life insurance coverage from accidents in the work place is provide to the employees by schemes such as VISWAS and SAFE, a special scheme for assistance to families in exigency, at a relatively low premium through internal trusts.

Key importance is laid to the competency requirements of the individuals, required for contributing effectively and efficiently towards realisation of the organisational goals and resulting achievements. Hence stringent recruitment process is adopted to ensure quality personnel are inducted into the system and greater importance is attached towards continuous development of the human resources, periodically in tune with the programmatic requirements.

The Centralised recruitments & Centre Specific recruitments are continued. However, due to Covid-19 impact and associated restrictions there has been delay in completing the process. With the revised mechanism evolved to complete the ongoing recruitment process, the centralised recruitments initiated during 2019 are completed during 2021. Actions are taken for initiation of recruitments for the year 2022.

ISRO/DOS has been absorbing bright graduates from the Indian Institute of Space Science and Technology (IIST) on successful completion of the B.Tech/Dual degree programme, meeting the benchmark set. The eleventh batch of students, who were admitted to B. Tech/ dual degree during September 2017 at IIST have graduated during September 2021 and a total of 86 eligible students are inducted in DOS/ISRO.

ISRO has established the 'Live Register' scheme, wherein a PG degree holder from foreign academic institution with minimum of two years of research experience in scientific/technical areas relevant to space and a PhD holder in specialised areas of studies in engineering/ technology/science relevant to the Indian Space programme can submit their dossiers to ISRO. The candidature is reviewed depending up on the suitability and recommendations of Centres. Till date opportunity has been extended to more than 281 candidates.

3.2.1 Training

Training & Development activities are envisaged through both, Centralised and Decentralised systems. The scheme of Centralised Induction Training Programme for newly joined scientist/ engineers, introduced during 2002, is being continued. The training programme is aimed at introducing the newly recruited engineers to the ISRO systems by providing necessary exposure to the ISRO programmes, achievements, rules, regulations, systems, processes, etc. Similar Centralised Induction Training programmes are being given to Office Assistants and Junior Personal Assistants in Administrative areas, conducted by different Centres/Units on a rotational basis. With regard to induction training programmes for other category of manpower, specific modules are designed and training is imparted at respective Centres.

Other programmes such as; Refresher courses for knowledge enhancement for technicians, technical assistants and technical support staff; Special training programmes for Administrative staff covering rules, procedures, systems and covering latest changes in the system; Training programmes for scientific/technical staff on specific technical topics of relevance in specific centres/units; Programmes on other relevant topics for other personnel, depending upon their specialization; General training programme to improve soft skills, computer skills, management & leadership aptitude, etc. are conducted as part of cadre training requirement. These training programmes are implemented both through centralised and de-centralised training programmes. Customised, exclusive management development training programmes for S&T personnel at middle level & executive level are organised through leading academic institutes.

In order to overcome the challenges posed by Covid-19, ISRO has embraced the on-line trainings.

3.2.1.1 Residential Skill Development Programme :

A Residential Skill Development Programme of four weeks in Aerospace Welding and Aerospace CNC Machining was organised during March – April 2021 in collaboration with National Skill Training Institute, Bengaluru, Directorate General of Training, Ministry of Skill Development & Entrepreneurship.

A batch of 20 NTC / NAC pass-out candidates below the age of twenty-five years at all Indian

3.2 Human Resource

level in each Aerospace Welding and Aerospace CNC Machining trade were selected for up-skill training at National Skill Training Institute, Bengaluru. The programme is sponsored by NewSpace India Limited under its Corporate Social Responsibility and Sustainability activities. The programme intends to create a skill pool of 40 technicians for futuristic needs for the growth of the Space sector in India in tandem with Skill India Mission कैशल भारत कुशल भारत.

The Residential Skill Development Programme is inaugurated virtually by Secretary, DOS/ Chairman, ISRO, Dr. K. Sivan in the presence of Sri Praveen Kumar, IAS, Secretary, Ministry of Skill Development & Entrepreneurship, Smt. Neelam Shami Rao, Director General, Directorate General of Training, Ministry of Skill Development & Entrepreneurship, Sri G. Narayanan Chief Managing Director, NewSpace India Limited and Sri TVLN Rao, Regional Director, RDSDE, Karnataka.

3.2.2.2 Workshop on Scientific Writing

An online workshop on "Scientific Writing" was organized by RESPOND, CBPO ISRO HQ on March 31, 2021 for the benefit of faculty, research scholars and others from academia, especially the research scholars working in the ISRO sponsored projects taken up under Space Technology Cells (STCs), Regional Academic Centre for Space (RAC-S), Space Technology Incubation Centres (S-TIC) and RESPOND.

The aim of this workshop was to create awareness about finding gaps in the existing literature, doing quality research, reproducibility of results, how to convert the work into a good research paper, publishing it in a reputed journal, how to choose a journal and ethics in publishing etc.

Awards & Recognition:

ISRO has instituted various schemes for recognising the contributions of consistent performers in various categories, namely Life time achievement award, outstanding achievement awards, performance excellence awards, merit awards, young scientist awards, service excellence awards and quality awards.

PROFORMA TO DOS LETTER NO.12022/4/2021-I DATED SEPTEMBER 21, 2021

MATERIAL FOR DOS ANNUAL REPORT (INFORMATION FROM 01.11.2020 TO 31.10.2021)

Sl. No	Details	Group-A		Group-B		Group-C	
A.	**GENERAL:** Total Number of Employees as on 31.10.2021	Sci/ Tech Staff	Admn Staff	Sci/ Tech Staff	Admn Staff	Sci/ Tech Staff	Admn Staff
	(i) Male Employees	7740	295	2250	883	1165	1162
	(ii) Female Employees	1837	165	189	796	60	254
B.	**SCHEDULED CASTES/ SCHEDULED TRIBES:**						
	(i) Number of Scheduled Caste Employees	691	57	399	249	196	270
	(ii) Number of Scheduled Tribe Employees	192	23	105	95	92	70
C.	**PERSONS WITH DISABILITIES (PWD):**						
	(i) Number of persons with disabilities existing as on 31.10.2021						
	1. Deaf & Dumb	14	1	18	7	11	4
	2. Blind	4	0	1	4	0	6
	3. Partially Blind	4	0	1	5	2	8
	4. Orthopaedically handicapped	120	10	75	42	24	11
	(ii) Number of Persons with dasabilities appointed during the year from 01.11.2020 to 31.10.2021						
	1. Deaf & Dumb	1	0	0	0	0	0
	2. Blind	0	0	0	0	0	0
	3. Partially Blind	4	0	0	0	0	0
	4. Orthopaedically handicapped	3	0	0	0	0	0

3.2 Human Resource

Sl. No	Details	Group-A		Group-B		Group-C	
D.	**EX-SERVICEMEN:**						
	(i) Number of Ex-servicemen existing as on 31.10.2021	14	5	36	55	32	210
	(ii) Number of Ex-servicemen appointed during the year from 01.11.2020 to 31.10.2021	0	0	0	0	1	4
E.	**OTHER BACKWARD CLASSES:**						
	(i) Number of OBCs existing as on 31.10.2021	2074	71	1141	448	649	512
	(ii) Number of OBCs appointed during the year from 01.11.2020 to 31.10.2021	46	2	3	2	10	14
F.	**APPRENTICES TRAINING:**						
	(i) Number of Apprentices trained during the year (From 01.11.2020 to 31.10.2021)			1230			
	(ii) Number of Apprentices appointed during the year from 01.11.2020 to 31.10.2021			1303			

STATUS OF SCHEDULED CASTE/SCHEDULED TRIBE PERSONNEL IN DOS/ISRO

TABLE - I

Sl. No	Centre/Unit	Total Strength of Employees as on October 31, 2021	Strength of SC Employees	Strength of ST Employees
1	DOS/ISRO HQ	447	56	25
2	VSSC	4627	361	50
3	URSC	2577	287	102
4	SDSC-SHAR	2153	332	125
5	SAC & DECU	2014	176	134
6	LPSC	1274	138	24
7	NRSC	851	111	43
8	ISTRAC	418	59	16
9	MCF	300	38	15
10	ADRIN	158	15	5
11	IIRS	84	11	4
12	PRL	272	13	7
13	SCL	562	110	7
14	NARL	72	11	1
15	NESAC	50	2	4
16	IIST	100	3	0
17	HSFC	150	6	4
18	IPRC	652	132	11
19	ANTRIX	18	1	0
20	NSIL	7	0	0
	TOTAL	**16786**	**1862**	**577**

3.2 Human Resource

STATUS OF PERSONS WITH DISABILITIES IN DOS/ISRO

TABLE - II

Sl No	Centre/Unit	Total Strength of Employees 2021-22	Strength of Persons with Disabilities	Classification of Employees with Disabilites			
				Deaf & Dumb	Blind	Partially Blind	Orthope-dically Handi-capped
1	DOS/ISRO HQ	447	6	0	0	0	6
2	VSSC	4627	107	21	6	12	68
3	URSC	2577	66	15	3	5	43
4	SDSC-SHAR	2153	49	2	2	0	45
5	SAC & DECU	2014	42	6	2	0	34
6	LPSC	1274	30	7	0	1	22
7	NRSC	851	21	2	1	1	17
8	ISTRAC	418	12	0	0	0	12
9	MCF	300	4	1	0	0	3
10	ADRIN	158	4	0	0	0	4
11	IIRS	84	5	0	1	0	4
12	PRL	272	5	1	0	0	4
13	SCL	562	4	0	0	0	4
14	NARL	72	1	0	0	0	1
15	NESAC	50	1	0	0	0	1
16	HSFC	150	0	0	0	0	0
17	IIST	100	1	0	0	0	1
18	IPRC	652	12	0	0	0	12
19	ANTRIX	18	1	0	0	0	1
20	NSIL	7	1	0	0	1	0
	TOTAL	**16786**	**372**	**55**	**15**	**20**	**282**

STATUS OF REPRESENTATION OF EX-SERVICEMEN IN DOS/ISRO

TABLE - III

Sl No	Centre/Unit	Total Number of Employees in Group - C 2021-22	Total Number of Ex-Servicemen in Group - C 2021-22
1	DOS/ISRO HQ	97	4
2	VSSC	634	122
3	URSC	404	12
4	SDSC-SHAR	521	21
5	SAC & DECU	342	7
6	LPSC	206	39
7	NRSC	131	9
8	ISTRAC	46	5
9	MCF	53	2
10	ADRIN	20	2
11	IIRS	4	1
12	PRL	17	0
13	SCL	53	3
14	NARL	7	0
15	NESAC	2	0
16	HSFC	3	0
17	IIST	0	0
18	IPRC	98	15
19	ANTRIX	3	0
20	NSIL	0	0
	TOTAL	**2641**	**242**

3.2 Human Resource

WOMEN EMPLOYEES IN DOS/ISRO

TABLE - IV

Sl No	Centre/Unit	Total Number of Women Employees 2021-22	Number of Women Employees	
			Scientific & Technical Staff	Administrative Staff
1	ISRO HQ	131	21	110
2	VSSC	995	549	446
3	URSC	718	575	143
4	SDSC-SHAR	238	124	114
5	SAC & DECU	335	259	76
6	LPSC	203	99	104
7	NRSC	208	147	61
8	ISTRAC	108	74	34
9	MCF	41	31	10
10	ADRIN	39	31	8
11	IIRS	23	18	5
12	PRL	48	29	19
13	SCL	58	37	21
14	NARL	13	8	5
15	NESAC	9	8	1
16	HSFC	19	10	9
17	IIST	26	20	6
18	IPRC	82	43	39
19	ANTRIX	5	2	3
20	NSIL	2	1	1
	TOTAL	**3301**	**2086**	**1215**

ECONOMICALLY WEAKER SECTION (EWS) IN DOS/ISRO

TABLE - V

Sl No	Name of the Centre	Total Number of Vacancies filled up for the period from 1.10.2020 to 30.09.2021	Strength of EWS employees
1	ISRO HQ	19	1
2	VSSC	0	0
3	URSC	32	0
4	SDSC-SHAR	20	1
5	SAC & DECU	0	0
6	LPSC	19	3
7	NRSC	6	0
8	ISTRAC	7	0
9	MCF	17	0
10	ADRIN	6	0
11	IIRS	1	0
12	PRL	5	0
13	SCL	1	0
14	NARL	2	0
15	NESAC	6	0
16	HSFC	0	0
17	IIST	0	0
18	IPRC	1	0
19	ANTRIX	-	-
20	NSIL	-	-
	TOTAL	**142**	**5**

3.3 Grant-in-aid

Details of Grant - In - Aid payment made in the year 2021, equal to or greater than Rupees Ten Lakhs

Sl. No.	Sanction Order No. & Date	Purpose of Grant	Name of the Grantee Institute	Released amount (Rs.)
1	B.19012/65/2015-Sec.2 Dt: 29.12.2020	Release of grant for the Space Technology Cell (STC) activities at Indian Institute of Technology (IIT), Kharagpur	Indian Institute of Technology (IIT), Kharagpur	1,67,53,335.00
2	DS_2B-13013(2)/1/2020-Sec.2 Dt: 12.01.2021	Release of grant to PRL for the initiation activities related to payloads recommended for the future planetary exploration	Physical Research Laboratory (PRL), Ahmedabad	15,00,000.00
3	DS_2B-13014/1/2020-Sec.2 Dt: 16.12.2020	Release of grant for carry out the project on soil mapping for 7 districts of Manipur state by NESAC	North East Space Application Center (NESAC), Shillong	15,75,000.00
4	DS_2B-13012(2)/55/2018-Sec.II Dt: 19.01.2021	Release of grant for the 5 ongoing projects taken under centre of excellence (CoE)	Indian Institute of Science (IISc), Bengaluru	69,71,000.00
5	B.19012/54/2015-Sec.2 Dt: 19.01.2021	Release of grant for the Space Technology Cell (STC) activities at Indian Institute of Technology (IIT), Kanpur	Indian Institute of Technology (IIT), Kanpur	1,50,00,000.00
6	DS_2B-13013(2)/29/2017 Dt: 22.01.2021	Multi- temporal interferometric SAR (MT-InSAR) studies for near real-time landslide monitoring.	Motilal Nehru National Institute of Technology, Allahabad	13,25,472.00
7	DS_2B-19012/106/2015 Sec.2 Dt: 19.01.2021	Release of grant for NIAS Ph.D Programmme for the year 2020-21	National Institute of Advanced Studies (NIAS), Bengaluru	20,00,000.00
8	DS_2B-19013/(2)1/2020 Sec.2 Dt: 12.01.2021	Release of grant to IIST for the initiation activities related to payloads recommended for the future planetary exploration	Indian Institute of Space Science and Technology (IIST)	10,00,000.00

Sl. No.	Sanction Order No. & Date	Purpose of Grant	Name of the Grantee Institute	Released amount (Rs.)
9	B.19012/119/2016 Sec.2 Dt: 19.01.2021	Release of grant for publication of current science journal during the year 2020-21	Current Science Association, Bengaluru	12,50,000.00
10	DS_2B.1301(2)/1/2020 Sec.2 Dt: 12.01.2021	Release of grant to NARL for the initiation activities related to payloads recommended for the future planetary exploration	National Atmospheric Research Laboratory (NARL)	15,00,000.00
11	DS_2B.13012(2)/19/2020 Sec.2 Dt: 29.01.2021	Estimation of thermal contact conductance of realistic spacecraft bolted joints	Indian Institute of Technology (IIT), Palakkad	18,33,000.00
12	DS_2B.13013(2)/1/2019 Sec.2 Dt: 05.02.2021	Release of grant for developmental activities of "INSIST" project under Future Astronomy AO	Indian Institute of Astrophysics, Bengaluru	16,00,000.00
13	DS_2B.19012/85/2015 Sec.2 Dt: 29.01.2021	Release of grant for the Space Technology Cell (STC) activities at Indian Institute of Science (IISc), Bengaluru during the year 2020-21	Indian Institute of Science (IISc), Bengaluru	1,05,81,500.00
14	DS_2B.13012(2)/13/2020 Sec.2 Dt: 11.02.2021	Release of grant for the Space Technology Cell (STC) activities at Indian Institute of Technology (IIT), Roorkee	Indian Institute of Technology (IIT), Roorkee, Uttarkand	97,33,500.00
15	B.19012/106/2015 Sec.2 Dt: 16.02.2021	Release of grant for NIAS Ph.D Programmme for the year 2020-21	National Institute of Advanced Studies (NIAS), Bengaluru	10,00,000.00
16	DS_2B.13012(2)31/2018 Sec.2 Dt: 05.02.2021	Study of a few persistent and transient black holes using ASTROSAT and other satellite data	Indian Centre for Space Physics, Kolkata	10,02,840.00
17	DS_2B_13013(2)/1/2019 Sec.II Dt: 05.02.2021	Release of grant for developmental activities of "PRATUSH" project under Future Astronomy AO	Raman Research Institute, Bengaluru	20,06,000.00

3.3 Grant-in-aid

Sl. No.	Sanction Order No. & Date	Purpose of Grant	Name of the Grantee Institute	Released amount (Rs.)
18	BDS_2B.13012(2)/14/2020 Sec.2 Dt: 11.11.2020	Release of grant for initiating activities related to 6 approved Technology Development Proposals (TDP) at Space Technology Incubation Centre (S-TIC) at National Institute of Technology (NIT), Tiruchirapalli during the year 2020-21	National Institute of Technology (NIT), Tiruchirapalli	16,69,833.00
19	DS_2B.13013(2)/1/2019 Sec.2 Dt: 05.02.2021	Release of grant for developmental activities of "SEAMS" project under Future Astronomy AO	Savitribai Phule Pune University (SPPU), Pune	26,00,000.00
20	DS_2B.13012(2)/11/2019 Sec.2 Dt: 23.02.2021	Release of grant for initiating activities related to approved technology development proposals(TDP) at space technology incubation centre(S-TIC) at national Institute of Technology, Agartala	National Institute of Technology (NIT), Agartala	12,43,547.00
21	DS_2B.13013(1)/1/2019 Sec.2 Dt: 11.03.2021	Release of grant for supporting Indian School Students Team participating in International Olympiads in Astronomy & Astrophysics	Homi Bhabha Centre for Science Education, Mumbai	21,47,000.00
22	B.19012/54/2015 Sec.2 Dt: 11.03.2021	Release of grant for the Space Technology Cell (STC) activities at Indian Institute of Technology Kanpur	Indian Institute of Technology (IIT), Kanpur	75,00,000.00
23	B.19013/3/2016 Sec.2 Dt: 19.03.2020	Release of Grant for funding to the ASTROSAT Support Cell (ASC) at IUCCA	Inter University Centre for Astronomy & Astrophysics (IUCAA), Pune	11,30,750.00
24	DS_2B-13012(2)/6/2021-Sec.2 Dt: 02.06.2021	Release of grants for activities of Regional Academic Centre (RAC) FOR Space at Malaviya National Institute of Technology	Malaviya National Institute of Technology (MNIT), Jaipur	36,47,716.00

Sl. No.	Sanction Order No. & Date	Purpose of Grant	Name of the Grantee Institute	Released amount (Rs.)
25	DS_2B-13012(2)/7/2021-Sec.2 Dt: 08.06.2021	Release of grant for the Space Technology Cell (STC) activities at Indian Institute of Technology Cell	Indian Institute of Technology (IIT), Delhi	38,60,500.00
26	B.19012/96/2016-Sec.2 Dt: 23.07.2021	Release of grant for the Space Technology Cell (STC) activities at Indian Institute of Technology Bombay	Indian Institute of Technology (IIT), Bombay	1,23,26,250.00
27	DS_2B-13012(2)/53/2018 Dt: 02.08.2021	Release of Third installment for the setting up of Satish Dhawan Centre for Space Science at Central University of Jammu	Central University of Jammu, J&K	4,74,73,200.00
28	B.19012/65/2015-Sec.2 Dt: 09.07.2021	Release of grant for the Space Technology Cell (STC) activities at Indian Institute of Technology (IIT), Kharagpur	Indian Institute of Technology (IIT), Kharagpur	47,72,000.00
29	DS_2B-13012(2)/35/2018-Sec.II Dt: 06.07.2021	Design and Fabrication of an interface ASIC for a vibratory gyroscope sensor application	Indian Institute of Technology (IIT), Mandi	10,01,592.00
30	DS_2B-13012(2)/9/2021-Sec.2 Dt: 20.07.2021	Release of grant for the Regional Academic Centre (RAC) for Space activities at Gauhati University	Gauhati University, Assam	22,62,528.00
31	B.19012/24/2014-Sec.2 Dt: 20.07.2021	Joint Research Programme (JRP) at Savitribai Phule Pune University (SPPU)	Savitribai Phule Pune University (SPPU), Pune	23,59,250.00
32	DS_2B.13012(2)/8/2021-Sec.2 Dt: 20.07.2021	Release of grant for the Space Technology Cell activities at Indian Institute of Technology (IIT), Guwahati	Indian Institute of Technology (IIT), Guwahati, Assam	51,23,070.00
33	DS_2B-13012(2)/55/2018-Sec.II Dt: 05.07.2021	Release of grant for the 5 ongoing projects taken under Centre of Excellence (CoE) on Advanced Mechanics of Materials	Indian Institute of Science (IISc), Bengaluru	97,12,000.00

3.3 Grant-in-aid

Sl. No.	Sanction Order No. & Date	Purpose of Grant	Name of the Grantee Institute	Released amount (Rs.)
34	B.19012/54/2015-Sec.2 Dt: 13.09.2021	Release of grant for Space Technology Cell (STC) Activities at Indian Institute of Technology (IIT), Kanpur	Indian Institute of Technology (IIT), Kanpur	50,28,000.00
35	DS-2B-13012(2)/13/2021-Sec.2 Dt: 06.09.2021	Machine Learning/Artificial Intelligence (ML/AI) Hardware/ Software for Vyomnoids	National Institute of Technology (NIT), Tiruchirapalli	20,12,000.00
36	DS-2B-13012(2)/10/2020-Sec.2 Dt: 21.09.2021	Estimation & tracking of Subsurface Groundwater Discharge (SGD) along Coastal stretches of AP & TN, based on understanding & Modelling of Coastal Aquifer Dynamics	Ponnaiyah Ramajayam Institute of Science & Technology (PRIST), TN	10,72,500.00
37	B.19012/85/2015-Sec.2 Dt: 08.10.2021	Release of grant for Space Technology Cell (STC) Activities at Indian Institute of Science (IISc)	Indian Institute of Science (IISc), Bengaluru	1,64,81,500.00
38	B.19012/104/2016-Sec.2 Dt: 29.10.2021	Release of grant for the Space Technology Cell (STC) activities at Indian Institute of Technology (IIT), Madras	Indian Institute of Technology (IIT), Madras	1,34,24,250.00
39	B.19012/54/2015-Sec.2 Dt: 29.10.2021	Release of grant for the Space Technology Cell (STC) activities at Indian Institute of Technology (IIT), Kanpur	Indian Institute of Technology (IIT), Kanpur	1,00,56,000.00
40	B.19013/3/2016-Sec.2 Dt: 15.11.2021	Release of Grant for funding to the ASTROSAT Support Cell at IUCCA	Inter University Centre for Astronomy & Astrophysics (IUCAA), Pune	16,91,196.00
41	DS-2B-13012(2)/32/2021-Sec.2 Dt: 17.11.2021	Spatio-spectral deconvolution of Hyperspectral images	Indian Institute of Technology (IIT), Indore	10,28,500.00
42	DS-2B-13012(2)/23/2021-Sec.2 Dt: 03.11.2021	Copper Coating on Epoxy-Carbon Composites for Radio Frequency Reflector Antennas	CSIR - National Institute for Interdisciplinary Science & Technology (NIIST), Thiruvananthapuram	12,58,900.00

Sl. No.	Sanction Order No. & Date	Purpose of Grant	Name of the Grantee Institute	Released amount (Rs.)
43	DS_2B-13012(2)/41/2018-Sec.2 Dt: 22.11.2021	Grant for the 8 ongoing Projects & 5 new Projects taken under Centre for Nano-Science & Engineering (CeNSE) - 3rd year for 8 Projects - 1st year for 5 projects	Indian Institute of Science (IISc), Bengaluru	4,31,04,000.00
44	DS_2B-13013(2)/1/2020-Sec.2 Dt: 22.11.2021	Release of grant to PRL for the initiation activities related to payloads recommended for the future planetary exploration during the year 2021-22	Physical Research Laboratory (PRL), Ahmedabad	17,00,000.00
45	DS-2B-13013(2)/77/2019-Sec.2 Dt: 30.11.2021	Release of grant for the Regional Academic Centre for Space at National Institute of Technology Karnataka Surathkal	National Institute of Technology (NIT) Karnataka, Surathkal	94,32,923.00
46	B.19012/119/2016-Sec.2 Dt: 20.12.2021	Release of Grant for publication Activities of Current Science Journal during 2021-22	Current Science Association, Bengaluru	12,50,000.00
47	DS-2B-13012(2)/35/2021-Sec.2 Dt: 17.11.2021	Catalyst Development of Hydrogen Peroxide dissociation for monopropellant Thrusters	National Institute of Technology (NIT), Warangal	10,25,750.00
48	DS-2B-13013(1)/2/2021-Sec.2 Dt: 12.11.2021	Release of grant for organizing "21st National Space Science Symposium-2022" by IISER, Kolkata	Indian Institute of Science, Education & Research (IISER), Kolkata	36,00,000.00
49	No.A.12021/1/2014-I (Vol.II) dt: 10.02.2021	Grant-in-aid to Vikram A. Sarabhai Trust (VAST) for administering the VAST Insurance Scheme Whenever Accident Strikes (VISWAS) for the financial year 2021-2022	Vikram A. Sarabhai Trust (VAST)	28,89,235.00
		Total		**30,05,15,637.00**

4

Others

4.1 Space in Parliament

Indian Space Programme continued to attract the attention of both the Houses of Parliament. Questions were answered in Parliament during January 2021 - December 2021 as shown below:

Questions	Budget Session 2021		Monsoon Session 2021		Winter Session 2021		Total	
	5th Session of 17th Lok Sabha	253rd Session of Rajya Sabha	6th Session of 17th Lok Sabha	254th Session of Rajya Sabha	7th Session of 17th Lok Sabha	255th Session of Rajya Sabha	LS	RS
Starred Questions	1	1	1	0	0	1	2	2
Unstarred Questions	19	7	5	8	12	11	36	26
Total	**20**	**8**	**6**	**8**	**12**	**12**	**38**	**28**

The Questions were with respect to Space Activities in India, Space Research Centers, Training of Astronauts, ISRO Facilities, Startups in India, Fund Allocation to ISRO, Missions of ISRO, Involvement of Private Sector Participation in Space, Space Assets, Generic Space Flight, Achievements in the Field of Space, Chandrayaan Mission, Space Facilities, Private Startups, Launch of Foreign Satellites, Space Policy, Commercializing Satellite Production, Chandrayaan-III, Private Satellite, Prime Minister's Vision for the Space Technology, Efforts Made to deal with Space Pollution, Adoption of Atal Tinkering Labs (ATLs) by ISRO, Indians in Space Arena, Space Waste, Space Debris, Danger of debris orbiting the Earth, Use of Infrastructure Facilities by Private Sector, Mars Mission, Satellite Launches from India, Communication of ISRO, Liquid Oxygen, Space Programmes, Space Race, Indian Regional Navigation Satellite Systems, Proposal for investment from private investors, Use of Space Applications for Digital Education, Collaboration with Brazil in Space Programme, Liberalisation of Space Sector, IoT for Industries, Recruitment in ISRO, Scientists of Indian Origin, Indian Space Promotion and Authorization Centre (IN-SPACe), Assistance to Small Island States, Manned Space Mission, New Space India Limited, Global Space Station, Space Programme, Collaboration with other countries in Space Research, Current Status of Mission Chandrayaan-3, Launch of Indian Space Association, Single Window Clearance in Space Exploration, Satellites launched by Indian Launch Vehicle, Agreement with foreign countries to launch satellites, Satellite Launch vehicle, Plan to develop reusable space craft, Gaganyaan Mission.

During the year 2021, Department-related Parliamentary Standing Committee on Science and Technology, Environment, Forests and Climate Change undertook a study visit to the Indian Institute of Remote Sensing (IIRS), Dehradun on November 23, 2021 and held a discussion with the representatives of the Institute and DOS.

4.2 Vigilance

Annexure-1

Category of employees	Types of cases	Cases pending as on 01.10.2020	Cases received during the period 01.10.2020 to 30.09.2021	Total (Col. 3+4)	Disposed during 01.10.2020 to 30.09.2021	Pending (Col. 5-6)
1	2	3	4	5	6	7
Group-A & Group B (Gazetted)	Disciplinary (Non-Vigilance)	12	2	14	2	12
	Vigilance	1	0	1	0	1
Group-B (Non-Gazetted) & Group C	Disciplinary (Non-Vigilance)	4	8	12	03	9
	Vigilance	1	0	1	0	1
	TOTAL	**18**	**20**	**28**	**5**	**23**

Annexure-2

Sl. No.	Particulars	
1	Number of complaints of sexual harassment received during the period 01.10.2020 to 30.09.2021	05
2	Number of complaints disposed of during the period 01.10.2020 to 30.09.2021	04
3	Number of workshops on awareness programmes against sexual harassment conducted during the period 01.10.2020 to 30.09.2021	05

4.3 Progressive use of Hindi

- This year too was a challenging year for Official Language Implementation, as was for other programs of the Department. During COVID-19 pandemic situation, implementation of Hindi in the DOS continued with the same vigour. The Official Language Implementation Committees (OLICs) held their quarterly meetings to review the progressive use of Hindi. DOS/ISRO and its Centers and Units also participated in the meetings of Town OLIC constituted in respective Towns. Modern communication tools and techniques were used for meetings/reviews.
- The Joint Hindi Advisory Committee (JHAC) of DOS and DAE was reconstituted. The resolution dated May 25, 2021 in this regard is published in the Gazette and the same was circulated to all concerned. The meeting of this committee will be convened after getting a suitable date from MoS, PMO.
- Every year, Department organizes the meeting of the Departmental Official Language Implementation Committee (DOLIC) to review the progressive use of Official Language in all the Centers/Units of DOS. In this connection, QPR's of all the Centers/Units were reviewed, and letters regarding this along with observations/suggestions were sent to the concerned Centers/Units. The meeting of DOLIC was convened under the Chairmanship of Additional Secretary, DOS with all the Centers/Units of the Department on July 29, 2021. For the very first time, this meeting was conducted through video mode. The higher officials from all the Center/Units of the Department participated in this meeting.
- Responsibilities of holding Secretariat post for TOLICs are undertaken by URSC, Bengaluru, MCF, Hassan and SCL, Chandigarh of the Department.
- All the Centres/Units of the Department located in 'A', 'B' and 'C' region achieved the targets of correspondence set by the Dept. of Official Language.
- During the year, Department and its Centres/Units purchased Hindi books for their Libraries, in accordance with the target set by DOL.
- In order to implement Hindi in more meaningful and effective manner, and to evaluate the progressive use of Hindi in DOS/ISRO Centers/Units, an Annual Inspection Program was drawn up by the Department. Due to the COVID-19 pandemic, the inspections were carried out this year mostly through online mode.
- Internal inspection of various Sections in ISRO HQ and in the Centers/Units was carried out to increase the use of Hindi in day-to-day work. Sections in DOS/ISRO HQ doing the best implementation of Official Language were awarded on 10.01.2022.
- Training programs in Hindi through Hindi Teaching Scheme under Correspondence

4.3 Progressive use of Hindi

courses continued in the Department. The percentage of employees possessing working knowledge of Hindi in all the DOS/ISRO Centres/Units considerably increased to about 80. The Centers/Units were requested to prepare an action plan for imparting training to the remaining employees and to complete the training programme at the earliest within the time schedule stipulated by DOL. Employees who are not yet trained will be given training in a phased manner.

- Employees who have successfully completed their language training programs appeared for the final exams in November 2021.
- Hindi Day, Hindi Week, Hindi Fortnight/Hindi Month and Hindi Workshops were organised, in all DOS/ISRO Centers/Units, during which competitions in Essay Writing, Noting and Drafting, Typing, Quiz, Elocution, Singing etc. were conducted. These competitions were organised for Hindi-speaking and non-Hindi speaking employees separately. The prizes were also awarded separately for both categories. Due to COVID-19 pandemic situation, all the competitions were conducted this year following all the guidelines issued in connection to COVID-19, including online.
- Hindi Fortnight prize distribution ceremony was organized on 12 Nov 2021 under the Chairmanship of Secretary, DOS/Chairman, ISRO. On this occasion, the prize winners of the competitions held during Hindi Fortnight and Children of the employees, who secured the highest marks in Hindi in 10th & 12th Standard Final exams were awarded.
- In order to implement the recommendations of the previous Joint Hindi Advisory Committee regarding the **propagation of Hindi from house to house**, family members of the employees were also invited during Hindi Fortnight celebrations in some Centers/ Units of the Department and there was an overwhelming response.
- World Hindi Day will be celebrated on January 10, 2022 in all Centers/Units of the Department through various programmes. On this occasion, in DOS/ISRO HQ. Hindi elocution competition was organized on 05.01.2020 for Hindi and Non-Hindi speaking categories. The topic for this competition was "**Role of Hindi in Indian freedom struggle**". All the prize winners were awarded on 10 Jan 2022.
- The Department always plays an active role in the activities of Town OLIC. It conducts various programmes under the auspices of Town OLIC. This year, on November 24, 2021, a Hindi written quiz competition was conducted for the participants of the member offices of the TOLIC (O-2) in Antariksh Bhavan. Also, many of the employees of DOS/ISRO HQ participated in the competitions organized by the other member offices and won prizes.
- 12th and 13th editions of 'DISHA', the in-house magazine of DOS/ISRO HQ, was published

during the year and consolidation of content has already been initiated for the next issue.

- In house Hindi magazines were brought out by various Centres/Units of the Department. As per the instructions issued by the Government of India all the Centers/Units have been advised for their digital release.
- Several Pamphlets, Panels/Posters connected to ISRO's launches and other outreach programs were brought out in Hindi.
- The website of the Department is bilingual and it is regularly updated in Hindi. In addition to Department's own Website, SAC, VSSC, PRL, NRSC, URSC and NARL also have their own Websites, which are updated in bilingual regularly. DOS/ISROHQ, SAC, VSSC, LPSC, SDSC also have internal web pages on the intranet.
- 'Hindi Month Incentive Scheme' under which the Officers/Employees doing maximum work in Hindi during the Hindi month are awarded continued during the year. The new incentive scheme of the Department "**SOLIS**" also continued during the year and employees of DOS/ ISRO HQ and its Centres/Units were awarded Cash Prizes & Certificates.
- Incentive Scheme, "**Vikram Sarabhai Hindi Maulik Lekhan Yojana**" was introduced to encourage the Scientists of the Department to write books on Scientific subjects in Hindi continued during the year. Under this scheme, 06 (Six) books from various ISRO Centers/ Units were received in the Department. These books were forwarded to the Members of the Committee for their review and comments. After the review process by the committee, the books are forwarded to the concerned Centers/Units for publication.
- Every year, various Centers/Units of the Department conduct Technical Seminars in Hindi on various subjects. In these seminars, a session on Official Language is also included. Seminar Souvenir is also brought out in electronic/Book form. But due to COVID-19 and the austerity measures taken by the Department, this year, only one Inter-Center Hindi Technical Seminar was to be conducted by VSSC. The topics for the seminar were:-

Technical Session- "Future direction of space research and application in India"

Official Language Session- "Specialities of Hindi in present scenario".

This Seminar was postponed due to the prevailing COVID-19 situation in Kerala and is now scheduled to be held in February 2022.

- Employees of DOS/ISRO Centres/Units also participated in the activities on progressive use of Hindi organized by various voluntary Organisations, Town OLIC and also by Regional Implementation Office.

4.3 Progressive use of Hindi

- Space Science Glossary of the Department is available in electronic form and is uploaded on the website for use by the general public.
- On September 30, 2021, inspection of NARL, Gadanki was completed by the second Sub-Committee of the Committee of Parliament on Official Language.
- In the Department, the task of inclusion of Hindi in **COINS** and, the web version of **COWAA** is underway at SDSC, Sriharikota.

AWARDS:

National Level -

- In-house Hindi magazine "GAGAN" of Vikram Sarabhai Space Center has been selected for "**Second Prize**" as the best In-house magazine in region 'C' under "**Rajbhasha Kirti Puraskar Scheme**".

TOLIC Level –

- ISTRAC, Bengaluru was awarded second prize for the year 2020-21 for outstanding Official Language Implementation by TOLIC (O-2), Bengaluru.
- ISRO HQ was awarded third prize for Official Language Implementation by TOLIC (O-2), Bengaluru.
- VSSC, Thiruvanthpuram, was awarded third prize for the year 2020-21 for outstanding Official Language Implementation by TOLIC, Thiruvanthpuram.

In-house Hindi magazine of VSSC "GAGAN" was awarded the second prize under the best In-house Hindi magazine category by TOLIC, Thiruvanthpuram.

RRSC, South was awarded the second prize for 2020-21 for outstanding Official Language Implementation by TOLIC (O-1), Bengaluru.

4.4 Right to Information

Right to Information (RTI) Act 2005 is implemented in this Department as per the mandate of RTI Act. With the increased RTI applications and in order to disseminate the information in time, Department of Space/ISRO had decentralized the adjudication of RTI applications/ appeals at Centres/Units/Autonomous Bodies/PSU level with effect from 01/11/2018. In terms of Section 5 & 19 of the Right to Information Act, 2005, all the DOS/ISRO Centres/Units/ Autonomous Bodies/PSU (Antrix) have identified and designated the Transparency Officer, Nodal Officer, Appellate Authority and Central Public Information Officer for implementation of RTI Act.

As per Section 4 (1) (b) of RTI Act, Department of Space has published the following information on the web page *https://www.isro.gov.in/*right-to-information

1. RTI Act
2. Guidelines for RTI Logo
3. Handbook on RTI Act
4. Guidelines for obtaining information under RTI Act
5. Suo moto disclosure under Section 4 (1) (b)
   - i. **The particulars of its organization, functions and duties**
     1. Organization Chart
     2. Work Allocation in Dept. of Space
     3. Functions and duties
   - ii. **The powers and duties of its officers and employees**
   - iii. **The procedure followed in the decision making process including channels of supervision and accountability**
   - iv. **The norms set by it for the discharge of its functions**
   - v. **The rules, regulations, instructions, manuals and records, held by it or under its control or used by its employees for discharging its functions**

     The rules and regulations formulated by the Government of India in the form of fundamental Rules, Supplementary Rules, General Financial Rules, Delegation of Financial Powers Rules, etc., are followed with suitable modifications, wherever required. The Following are the rules, manuals, etc., held by the Department of Space used by its employees for discharging its functions:

     1. Fundamental Rules

4.4 Right to Information

2. Supplementary Rules
3. General Financial Rules
4. Conduct Rules
5. DOS Employees (CCA Rules)
    1. DOS Employees – CCA Rules – 1976
    2. DOS Employees – CCA Rules – Amendment October 2017
    3. DOS Employees – CCA Rules – Amendment January 2019
    4. DOS Employees – CCA Rules – Amendment October 2019
6. DOS Study Leave Rules
    1. Study Leave Rules (Upto 1997)
    2. Study Leave Rules – Amendment – 2006
    3. Study Leave Rules – Amendment – 2015
    4. Study Leave Rules – Amendment – 2021
7. DOS Allotment of Residence Rules
8. DOS Book of Financial Powers
9. DOS Purchase Manual
10. DOS Stores Procedure
11. Transfer Policy – Transfer and posting of Officers in Administrative areas - guidelines

vi. A Statement of the categories of documents that are held by it or under its control

vii. The particulars of any arrangement that exists for consultation with or representation by the members of the public in relation to the formulation of its policy or implementation thereof.

viii. A statement of the boards, councils, committees and other bodies consisting of two or more persons constituted as its part or for the purpose of its advise and as to whether meetings of those boards, councils, committees and other bodies are open to the public or the minutes of such meetings are accessible for public.

1. Statement of boards, councils, committees and other bodies, and as to whether meetings of such boards, etc., are open to public

ix. A directory of its officers and employees

x. The monthly remuneration received by each of its officers and employees including the system of compensation as provided in its regulations.

xi. The budget allocated to each of its agency indicating the particulars of all plans, proposed expenditures and reports on disbursements made.

xii. The manner of execution of subsidy programmes including the amounts allocated and the details of beneficiaries of such programmes.

xiii. Particulars of recipients of concessions, permits or authorizations granted by it.

xiv. Details in respect of the information available to or held by it reduced in an electronic form.

The relevant documents relating to procurement management, personnel management and management of services are held by the Department. The following documents are held by the Department:

1. Demands for Grants
    1. Archive of Demands for Grants since 1972
2. Annual Report
3. DOS Purchase Manual
4. DOS Stores Procedure
5. DOS Book of Financial Powers
6. DOS Employees (CCA Rules)
    1. DOS Employees – CCA Rules – 1976
    2. DOS Employees – CCA Rules – Amendment October 2017
    3. DOS Employees – CCA Rules – Amendment January 2019
    4. DOS Employees – CCA Rules – Amendment October 2019
7. DOS Study Leave Rules
    1. Study Leave Rules (Upto 1997)
    2. Study Leave Rules – Amendment – 2006
    3. Study Leave Rules – Amendment – 2015
    4. Study Leave Rules – Amendment – 2021
    8. DOS Allotment of Residence Rules
    9. Norms for Recruitment and Career Prospects
    10. Transfer policy - Transfer and posting of Officers in Administrative areas – guidelines

The above documents are available in electronic form only and no copies are available for sale.

4.4 Right to Information

xv. The particulars of facilities available to citizens for obtaining information including the working hours of a library or reading room, if maintained for public use.

xvi. The names, designations and other particulars of the Public Information Officers

1. List of Transparency Officer, Nodal Officers, Appellate Authority, Central Public Information Officers in DOS
2. List of Earlier CPIOs & FAAs from 1.1.2015

xvii. Other Information

1. Official tours of Officers at the level of Joint Secretary (JS) & above.
    1. January 2021 to March 2021
    2. April 2021 to June 2021
    3. July 2021 to September 2021
2. Telephone numbers and addresses of Secretary and other Officers/Officials of Department of Space dealing with Parliament work
3. Transfer and Posting of Officers in Administrative Areas
4. Audit Report of the DOS/ISRO on proactive disclosure under RTI Act, 2005 (May 2017)
5. Details of tender bids awarded, names of suppliers, rates and total amount
6. Information regarding CAG and PAC paras as well as action taken reports (ATR) on those paras which have been laid on the table of both houses of parliament
7. Frequently asked Questions (FAQs)

6. List of PIOs and APIOs of DOS and ISRO Centres

7. Information under section 25(3) of right to information Act, 2005

8. Annual Report

9. Human Resources

10. Citizen's Charter

11. Public Grievances

12. ISROs Timeline from 1960s to Today

During the period December 2020 to November 2021, 2300 applications were received and information was disseminated under the provisions of the RTI Act. 279 Appeals were received by the First Appellate Authority and 24 appellants approached the Second Appellate Authority, i.e., Central Information Commission.

4.5 Audit Observation

A. Status of the Action Taken Note (ATN)

			Details of the Paras/PA reports on which ATNs are pending			
Sl. No	Year	No. of Paras/ PAC reports on which ATNs have been submitted to PAC after vetting by Audit	No. of ATNs not sent by the Ministry even for the first time	No. of ATNs sent by the Ministry and awaiting vetting by Audit	No. of ATNs sent but returned with observations and Audit is awaiting their resubmission by the Ministry	No. of ATNs which have been finally vetted by audit but have not been submitted by the Ministry to PAC
1	**2**	**3**	**4**	**5**	**6**	**7**
1	Report No.17 of 2017 (Para No.6.1) Management of VSAT services	One	Nil	Nil	Nil	Nil
2	Report No.17 of 2017 (Para No.6.2) Irregular expenditure on pre-project activities	One	Nil	Nil	Nil	Nil
3	Report No.17 of 2017 (Para No.6.3) Lack of financial prudence and improper contract management – delivery of commercial space crafts	One	Nil	Nil	Nil	Nil
4	Report No.17 of 2017 (Para No.6.4) Infructuous expenditure in purchase of ecologically fragile land	One	Nil	Nil	Nil	Nil

4.5 Audit Observation

5	Report No.2 of 2018 (Para No.7.1) Operationalisation of Satellite Navigational system	One	Nil	Nil	Nil	Nil
6	Report No.2 of 2018 (Para No.7.2) Infructuous expenditure on software development	One	Nil	Nil	Nil	Nil
7	Report No.6 of 2020 (Para No. 5.1) Grant of additional increments	One	Nil	Nil	Nil	Nil
8	Report No.6 of 2020 (Para No. 5.2) SiC mirror development facility	One	Nil	Nil	Nil	Nil
9	Report No.6 of 2020 (Para No. 5.3) Creation of posts without the approval of competent authority	One	Nil	Nil	Nil	Nil
10	Report No.6 of 2020 (Para No. 5.4) Residency period for promotion fixed at lower than prescribed level	One	Nil	Nil	Nil	Nil
11	Report No.6 of 2020 (Para No.5.5) Management of civil works	One	Nil	Nil	Nil	Nil

Milestones

1962

- Indian National Committee for Space Research formed and works on establishing Thumba Equatorial Rocket Launching Station (TERLS), started

1963

- First sounding rocket launch from TERLS (November 21, 1963)

1965

- Space Science and Technology Centre (SSTC) established in Thumba

1967

- Experimental Satellite Communication Earth Station (ESCES) set up at Ahmedabad

1968

- TERLS dedicated to the United Nations (February 2, 1968)

1969

- ISRO formed (August 15, 1969)

1972

- Space Commission and DOS set up. ISRO brought under DOS (June 1, 1972)

1972-76

- Air-borne remote sensing experiments

1975

- ISRO becomes Government Organisation (April 1, 1975)
- First Indian Satellite, Aryabhata, launched (April 19, 1975)

1975-76

- Satellite Instructional Television Experiment (SITE) conducted

1977-79

- Satellite Telecommunication Experimental Project (STEP) carried out

1979

- Bhaskara-I, an experimental satellite for earth observations, launched (June 7, 1979)
- First Experimental launch of SLV-3 with Rohini Technology Payload onboard (August 10, 1979). The satellite could not be placed in orbit.

1980

- Second Experimental launch of SLV-3. Rohini satellite successfully placed in orbit (July 18, 1980)

1981

- First developmental launch of SLV-3. RS-D1 placed in orbit (May 31, 1981)
- APPLE, an experimental geostationary communication satellite successfully launched (June 19, 1981)
- Bhaskara-II launched (November 20, 1981)

1982

- INSAT-1A launched (April 10, 1982). Deactivated on September 6, 1982

1983

- Second developmental launch of SLV-3. RS-D2 placed in orbit (April 17, 1983)
- INSAT-1B launched (August 30, 1983)

1984

- Indo-Soviet manned space mission (April 1984)

1987

- First developmental launch of ASLV with SROSS-1 satellite onboard (March 24, 1987). The satellite could not be placed in orbit

1988

- Launch of first operational Indian Remote Sensing satellite, IRS-1A (March 17, 1988)
- Second developmental launch of ASLV with SROSS-2 onboard (July 13, 1988). The satellite could not be placed in orbit
- INSAT-1C launched (July 22, 1988). Abandoned in November 1989

1990

- INSAT-1D launched (June 12, 1990)
- Launch of second operational Remote Sensing satellite, IRS-1B (August 29, 1991)

1992

- Third developmental launch of ASLV with SROSS-C on board (May 20, 1992). Satellite placed in orbit
- INSAT-2A, the first satellite of the indigenously-built second-generation INSAT series, launched (July 10, 1992)

1993

- INSAT-2B, the second satellite in INSAT-2 series, launched (July 23, 1993)
- PSLV-D1, the first developmental launch of PSLV with IRS-1E onboard (September 20, 1993). The satellite could not be placed in orbit

1994

- Fourth developmental launch of ASLV with SROSS-C2 onboard (May 4, 1994). Satellite placed in orbit
- PSLV-D2, the second developmental launch of PSLV with IRS-P2 onboard (October 15, 1994). The satellite was successfully placed in Polar Sun Synchronous Orbit.

1995

- INSAT-2C, the third satellite in INSAT-2 series, launched (December 7, 1995)
- Launch of third operational Indian Remote Sensing Satellite, IRS-1C (December 28, 1995)

1996

- PSLV-D3, the third developmental launch of PSLV with IRS-P3 onboard (March 21, 1996). Satellite placed in Polar Sun Synchronous Orbit

1997

- INSAT-2D, the fourth satellite in INSAT-2 series, was launched (June 4, 1997). Becomes inoperable on October 4, 1997. (An in-orbit satellite, ARABSAT-1C, later renamed INSAT-2DT, was acquired in November 1997 to partly augment the INSAT system)
- PSLV-C1, the first operational launch of PSLV with IRS-1D onboard (September 29, 1997). Satellite placed in orbit

1998

- INSAT system capacity augmented with the readiness of INSAT-2DT acquired from ARABSAT (January 1998)

1999

- INSAT-2E, the last satellite in the multipurpose INSAT-2 series, launched by Ariane from Kourou, French Guyana (April 3, 1999)
- Indian Remote Sensing Satellite, IRS-P4 (Oceansat-1), launched by Polar Satellite Launch Vehicle (PSLV-C2) along with Korean KITSAT-3 and German DLR-TUBSAT from SDSC SHAR, Sriharikota (May 26, 1999)

2000

- INSAT-3B, the first satellite in the third generation INSAT-3 series, launched by Ariane from Kourou, French Guyana (March 22, 2000)

2001

- Successful flight test of Geosynchronous Satellite Launch Vehicle (GSLV-D1) on April 18, 2001, with an experimental satellite GSAT-1 onboard
- Successful launch of PSLV-C3 on October 22, 2001, placing three satellites – India's TES, Belgian PROBA and German BIRD into Polar Sun Synchronous Orbit

2002

- Successful launch of INSAT-3C by Ariane from Kourou, French Guyana (January 24, 2002)
- Successful launch of KALPANA-1 by ISRO's PSLV-C4 from SDSC SHAR (September 12, 2002)

2003

- Successful launch of INSAT-3A by Ariane from Kourou, French Guyana (April 10, 2003)
- Successful launch of GSLV-D2, the second developmental test flight of GSLV with GSAT-2 onboard from SDSC SHAR (May 8, 2003)
- Successful launch of INSAT-3E by Ariane from Kourou, French Guyana (September 28, 2003)
- Successful launch of Resourcesat-1 by ISRO's PSLV-C5 from SDSC SHAR (October 17, 2003)

2004

- GSLV-F01, the first operational flight of GSLV from SDSC SHAR. EDUSAT successfully placed in GTO (September 20, 2004)

2005

- Successful launch of Cartosat-1 and HAMSAT by PSLV-C6 from the newly established Second Launch Pad at SDSC SHAR (May 5, 2005)
- Successful launch of INSAT-4A by Ariane from Kourou, French Guyana (December 22, 2005)

2006

- GSLV-F02, the second operational flight of GSLV from SDSC SHAR with INSAT-4C onboard (July 10, 2006). The satellite could not be placed in orbit

2007

- PSLV-C7 successfully launches four satellites – India's Cartosat-2 and Space Capsule Recovery Experiment (SRE-1) as well as Indonesia's LAPAN-TUBSAT and Argentina's PEHUENSAT-1 (January 10, 2007)
- Successful recovery of SRE-1 after manoeuvring it to re-enter the earth's atmosphere and descend over the Bay of Bengal about 140 km East of Sriharikota (January 22, 2007)
- Successful launch of INSAT-4B by Ariane launch vehicle from Korou, French Guyana on March 12, 2007
- PSLV-C8 successfully launched an Italian satellite AGILE on April 23, 2007, under a commercial contract with Antrix Corporation
- Launch of GSLV-F04 with INSAT-4CR onboard from SDSC SHAR on September 2, 2007

2008

- PSLV-C10successfully launches TECSAR satellite on January 21, 2008, under a commercial contract with Antrix Corporation
- PSLV-C9 successfully launched ten satellites on April 28, 2008: India's Cartosat-2A, Indian Mini Satellite-1 (IMS-1) and eight Nanosatellites for International Customers under a commercial contract with Antrix Corporation

- PSLV-C11 successfully launched Chandrayaan-1 spacecraft on October 22, 2008
- European Ariane-5 launch vehicle successfully launches W2M satellite on December 21, 2008, jointly built by Antrix / ISRO and EADS Astrium on a commercial basis

2009

- PSLV-C12 successfully launches RISAT-2 and ANUSAT, on April 20, 2009
- PSLV-C14 successfully launches Oceansat-2 and six nanosatellites for international customers under a commercial contract with Antrix Corporation (September 23, 2009)

2010

- Successful static testing of GSLV Mk-III Launch Vehicle's S200 Solid Propellant Booster Rocket Stage (January 24, 2010)
- GSLV-D3, the first launch of GSLV with indigenous Cryogenic Upper Stage and GSAT-4 satellite onboard. GSAT-4 could not be placed in orbit (April 15, 2010)
- PSLV-C15, the seventeenth flight of PSLV, successfully launches India's Cartosat-2B and STUDSAT, Algeria's ALSAT-2A, Canada's NLS-1 and NLS-2 on (July 12, 2010).
- Successful Static Testing of GSLV Mk-III Launch Vehicle's L110 Liquid Core Stage (September 8, 2010)
- European Ariane-5 launch vehicle successfully launches HYLAS satellite on November 27, 2010, jointly built by Antrix / ISRO and EADS Astrium on a commercial basis
- GSLV-F06, the seventh launch of GSLV with GSAT-5P satellite onboard, could not place the satellite in orbit (December 25, 2010)

2011

- PSLV-C16 successfully launches India's Resourcesat-2, YOUTHSAT and X-SAT from Singapore on April 20, 2011
- GSAT-8 Communication Satellite launched by Ariane launcher from Kourou, French Guiana on May 21, 2011
- PSLV-C17 successfully launched GSAT-12 Communication Satellite on July 15, 2011
- Second successful static testing of S-200 booster to be used in GSLV Mk-III on September 4, 2011
- PSLV-C18 successfully launches the Indo-French satellite Megha-Tropiques and three co-passenger satellites – Jugnu from IIT, Kanpur, SRMSat from SRM University, Chennai and VesselSat–1 from Luxembourg – on October 12, 2011

2012

- PSLV, in its twenty-first flight (PSLV-C19), launched India's first Radar Imaging Satellite (RISAT-1) from Sriharikota on April 26, 2012
- In its twenty-second flight (PSLV-C21), PSLV successfully launched French earth observation satellite SPOT-6 along with Japanese microsatellite PROITERES from Sriharikota on September 09, 2012

- India's heaviest communication satellite, GSAT-10, successfully launched by Ariane-5 VA 209 from Kourou, French Guiana, on September 29, 2012

2013

- PSLV, in its twenty-third flight (PSLV-C20), successfully launched Indo-French Satellite SARAL along with six smaller satellites from abroad from Sriharikota on February 25, 2013
- PSLV, in its twenty-fourth flight (PSLV-C22), successfully launched India's first dedicated navigation satellite IRNSS-1A from Sriharikota on July 01, 2013
- India's advanced weather satellite INSAT-3D successfully launched by Ariane-5 VA-214 from Kourou, French Guiana, on July 26, 2013
- India's advanced communication satellite GSAT-7 successfully launched by Ariane-5 VA-215 from Kourou, French Guiana, on August 30, 2013
- Mars Orbiter Mission, India's first interplanetary mission to planet Mars, was successfully launched by PSLV-C25 from Sriharikota on November 05, 2013
- Trans Mars Injection Manoeuvre performed on Mars Orbiter Spacecraft on December 01, 2013, to place it in Mars Transfer Trajectory

2014

- In its first successful flight with indigenous Cryogenic Upper Stage, GSLV-D5 successfully placed GSAT-14 into GTO on January 05, 2014
- PSLV, in its twenty-sixth flight (PSLV-C24), successfully launched IRNSS-1B, the second satellite of the Indian Regional Navigation Satellite System (IRNSS) from SDSC SHAR, Sriharikota, on April 04, 2014
- PSLV-C23 Successfully launches French Earth Observation Satellite- SPOT 7 and four other co-passenger satellites from SDSC SHAR, Sriharikota on June 30, 2014
- India's Mars Orbiter Spacecraft successfully entered into an orbit around planet Mars on September 24, 2014
- PSLV, in its twenty-eighth flight (PSLV-C26) successfully launched IRNSS-1C, the third satellite of the Indian Regional Navigation Satellite System (IRNSS) from SDSC SHAR, Sriharikota, on October 16, 2014
- India's communication satellite, GSAT-16 successfully launched by the Ariane-5 VA221 from Kourou, French Guiana, on December 07, 2014.
- The first experimental suborbital flight (LVM3-X / CARE) of India's next-generation launch vehicle LVM3 (GSLV Mk-III) was successfully conducted from Satish Dhawan Space Centre SHAR, Sriharikota on December 18, 2014. CARE module carried onboard to a height of 126 km successfully recovered

2015

- PSLV-C27 Successfully Launches India's Fourth Navigation Satellite IRNSS-1D on March 28, 2015 from SHAR, Sriharikota.

- PSLV-C28 successfully launches three identical DMC3 commercial Earth Observation Satellites, along with two smaller satellites from the United Kingdom, into a polar Sun Synchronous Orbit on July 10, 2015, from SHAR, Sriharikota.
- Geo-Synchronous Satellite Launch Vehicle (GSLV-D6), equipped with the indigenous Cryogenic Upper Stage (CUS), successfully launches 2117 kg GSAT-6 into a GTO on August 27, 2015, from SHAR, Sriharikota.
- AstroSat, India's first dedicated astronomy satellite successfully launched by PSLV-C30 on September 28, 2015, from SHAR,. Along with AstroSat, six satellites from international customers - LAPAN-A2 of Indonesia, NLS-14 (Ev9) of Canada and four identical LEMUR satellites of USA – were also launched by this PSLV flight.
- The 3164 kg GSAT-15 carrying Ku-band transponders and GAGAN payload launched successfully by the European Ariane-5 VA-227 from Kourou, French Guiana, on November 11, 2015.
- In its thirty second flight conducted from SDSC SHAR, Sriharikota on December 16, 2015, PSLV-C29 successfully launched six satellites from Singapore (400 kg TeLEOS-1 as primary satellite and other Five co-passenger payloads).

2016

- The Polar Satellite Launch Vehicle, in its 33rd flight (PSLV-C31), launches IRNSS-1E, the fifth satellite of the Indian Regional Navigation Satellite System (IRNSS) on January 20, 2016, from SDSC SHAR, Sriharikota.
- The Polar Satellite Launch Vehicle, in its 34th flight (PSLV-C32), launches IRNSS-1F, the sixth satellite of the Indian Regional Navigational Satellite System (IRNSS) on March 10, 2016, from SDSC SHAR, Sriharikota.
- The Polar Satellite Launch Vehicle, in its 35th flight (PSLV-C33), launches IRNSS-1G, the seventh satellite of the Indian Regional Navigation Satellite System (IRNSS), into a Sub-Geosynchronous Transfer Orbit (Sub-GTO) on April 28, 2016, from SDSC SHAR, Sriharikota.
- India's Reusable Launch Vehicle-Technology Demonstrator (RLV-TD), successfully flight tested on May 23, 2016, from SDSC SHAR, Sriharikota. RLV-TD is one of the most technologically challenging endeavors of ISRO towards developing essential technologies for a fully reusable launch vehicle to enable low-cost access to space.
- India's Polar Satellite Launch Vehicle, in its 36th flight (PSLV-C34), launches the 727.5 kg Cartosat-2 Series Satellite for earth observation and 19 co-passenger satellites together weighing about 560 kg at lift-off into a 505 km polar Sun Synchronous Orbit (SSO) on June 22, 2016, from Sriharikota. The co-passenger satellites are from USA, Canada, Germany and Indonesia, as well as two satellites (SATHYABAMASAT and SWAYAM) from Indian University / Academic Institute.
- The first experimental mission of ISRO's Scramjet Engine towards the realisation of an Air Breathing Propulsion System was successfully conducted on August 28, 2016, from SHAR.
- India's Geosynchronous Satellite Launch Vehicle (GSLV), in its tenth flight (GSLV-F05), launches INSAT-3DR, an advanced weather satellite, weighing 2,211 kg into a Geostationary Transfer Orbit (GTO) on September 08, 2016, from SDSC SHAR, Sriharikota.

- India's Polar Satellite Launch Vehicle, in its 37th flight (PSLV-C35), launches the 371 kg SCATSAT-1 for weather-related studies and seven co-passenger satellites into polar Sun Synchronous Orbit (SSO) on September 26, 2016, from SDSC SHAR Sriharikota.
- Co-passenger satellites are ALSAT-1B, ALSAT-2B, ALSAT-1N from Algeria, NLS-19 from Canada and Pathfinder-1 from USA as well as two satellites PRATHAM from IIT Bombay and PISAT from PES University, Bengaluru.
- India's latest communication satellite, GSAT-18, was inducted into the INSAT / GSAT system on October 06, 2016, from Kourou, French Guiana by Ariane-5 VA-231. Weighing 3,404 kg at lift-off, GSAT-18 carries 48 communication transponders to provide services in Normal C-band, Upper Extended C-band and Ku-bands of the frequency spectrum along with a Ku-band beacon for accurately pointing ground antennas towards the satellite.
- In its 38th flight (PSLV-C36), ISRO's Polar Satellite Launch Vehicle successfully launched 1,235 kg Resourcesat-2A Satellite on December 07, 2016, from Satish Dhawan Space Centre SHAR, Sriharikota. This is the 37th consecutively successful mission of PSLV.

2017

- In its thirty-ninth flight (PSLV-C37), ISRO's Polar Satellite Launch Vehicle successfully launched the 714 kg Cartosat-2 Series Satellite along with 103 co-passenger satellites on February 15, 2017, from SHAR, Sriharikota. This is the thirty-eighth consecutively successful mission of PSLV. The total weight of all the 104 satellites carried onboard PSLV-C37 was 1378 kg. This is the highest number of satellites launched in a Single Flight.
- India's Geosynchronous Satellite Launch Vehicle, in its eleventh flight (GSLV-F09), successfully launched the 2230 kg South Asia Satellite (GSAT-9) from SDSC SHAR, Sriharikota, into its planned Geosynchronous Transfer Orbit (GTO) on May 05, 2017. This is the fourth consecutive success achieved by GSLV carrying indigenously developed Cryogenic Upper Stage.
- The first developmental flight (GSLVMk-III D1) of India's heavy-lift launch vehicle GSLV Mk-III was successfully conducted on June 05, 2017, from SHAR, Sriharikota, with the launch of the GSAT-19 satellite. This was the first orbital mission of GSLVMk-III, which was mainly intended to evaluate the vehicle performance including that of its fully indigenous cryogenic upper stage during the flight. Weighing 3136 kg at lift-off, GSAT-19 is the heaviest satellite launched from Indian soil.
- ISRO's Polar Satellite Launch Vehicle PSLV-C38 successfully launched the 712 kg Cartosat-2 Series Satellite along with 30 co-passenger satellites on June 23, 2017 from SHAR, Sriharikota. This is the thirty-ninth consecutively successful mission of PSLV.
- India's latest communication satellite, GSAT-17, was inducted into the INSAT/GSAT system on June 29, 2017, from Kourou, French Guiana by Ariane-5 VA-238. The 3477 kg GSAT-17 carries communication payloads in C-band, Extended C-band and S-band for providing various services to the country. The satellite also carries equipment for meteorological data relay and satellite-based search and rescue services.
- The forty-first flight of India's Polar Satellite Launch Vehicle (PSLV-C39), carrying

IRNSS-1H Navigation Satellite, conducted on August 31, 2017, from Satish Dhawan Space Centre SHAR, Sriharikota, was unsuccessful.

2018

- In its 42nd flight, PSLV-C40 successfully launched the 710 kg Cartosat-2 Series Remote Sensing Satellite along with 30 co-passenger satellites on January 12, 2018, from SHAR, Sriharikota. The co-passenger satellites comprise one Microsatellite and one Nanosatellite from India as well as 3 Microsatellites and 25 Nanosatellites from six countries, namely, Canada, Finland, France, Republic of Korea, UK and USA.
- GSLV-F08, in its 12th flight of Geosynchronous Satellite Launch Vehicle (GSLV) launched GSAT-6A from the Second Launch Pad (SLP) in SHAR, Sriharikota on March 29, 2018. However, the satellite lost communication with the ground station.
- India's Polar Satellite Launch Vehicle, in its forty-third flight (PSLV-C41) in, launched IRNSS-1I Satellite from First Launch Pad (FLP) of SDSC SHAR, Sriharikota on April 12, 2018. The IRNSS-1I is the eighth satellite to join the NavIC navigation satellite constellation.
- A major technology demonstrator called as Pad Abort Test was successfully carried out at SHAR, Sriharikota, on July 05, 2018. This was one of the tests to qualify a Crew Escape System, which is a critical technology in human spaceflight. The first Pad Abort Test demonstrated the safe recovery of the crew module in case of any exigency at the launch pad.
- PSLV-C42 Successfully Launched two foreign satellites from SDSC, SHAR, Sriharikota on September 16, 2018. This mission launched two earth observation satellites, NovaSAR and S1-4 (together weighing nearly 889 kg) of M/s Surrey Satellite Technologies Limited (SSTL), the United Kingdom under commercial arrangement with Antrix Corporation Limited.
- On November 14, 2018 GSLV Mk-III D2 successfully launched a communication satellite, GSAT-29, into the orbit weighing about 3423 kg from SDSC SHAR, Sriharikota.
- PSLV-C43, on November 29, 2018, successfully launched India's Hyperspectral Imaging Satellite (HysIS) and 30 international co-passenger satellites. HysIS, the primary satellite of the PSLV-C43 mission, weighing about 380 kg, is an earth observation satellite configured around ISRO's Mini Satellite-2 (IMS-2) bus. The co-passengers of HysIS include 1 Microsatellite and 29 Nanosatellites from 8 different countries. These satellites have been commercially contracted for launch through Antrix Corporation Limited, the commercial arm of ISRO.
- ISRO's next-generation high throughput communication satellite, GSAT-11, was successfully launched on December 05, 2018, from Kourou launch base, French Guiana, by Ariane-5 VA-246. Weighing about 5854 kg, GSAT-11 is the heaviest satellite built by ISRO. GSAT-11 is the forerunner in the series of advanced communication satellites with multi-spot beam antenna coverage over the Indian mainland and Islands. GSAT-11 will play a vital role in providing broadband services across the country. It will also provide a platform to demonstrate new generation applications.
- GSLV-F11 successfully launched GSAT-7A, ISRO's 39th communication satellite, on

December 19, 2018, from the Second Launch Pad (SLP) of SHAR, Sriharikota. GSAT-7A, with a lift-off mass of 2250 kg, is a geostationary satellite carrying communication transponders in Ku-band. The Satellite is built to provide communication capability to the users over the Indian region.

2019

- PSLV-C44 successfully launched Microsat-R and Kalamsat-V2 on January 24, 2019, from Sriharikota.
- On February 06, 2019, GSAT 31 was successfully launched from Kourou, French Guiana, on board Arianespace rocket.
- EMISAT and 28 customer satellites were successfully launched onboard PSLV-C45 on April 01, 2019, from Sriharikota. The launch viewing gallery was inaugurated and opened to the public for viewing launches live from Sriharikota.
- On May 22, 2019, RISAT-2B satellite was successfully launched onboard PSLV-C46 from Sriharikota.
- Chandrayaan-2 satellite was successfully launched into an earth orbit by GSLV Mk-III M1 on July 22, 2019.
- On November 27, 2019, Cartosat-3 and 13 customer satellites were successfully launched by PSLV-C47 from Sriharikota.
- On December 11, 2019, PSLV-C48 successfully launched RISAT-2BR1 satellite and 9 customer satellites from Sriharikota.

2020

- On January 17, 2020, GSAT-30 was successfully launched from Kourou, French Guiana, on board the Arianespace Ariane-5 VA-251 rocket.
- EOS-01 and nine customer satellites were successfully launched by PSLV-C49 on November 07, 2020, from Sriharikota.
- PSLV-C50 successfully launched CMS-01 on December 17, 2020, from Sriharikota.

2021

- On February 28, 2021, PSLV-C51 successfully launched Amazonia-1 and 18 co-passenger satellites from Sriharikota. It marked the first dedicated launch for NSIL.
- GSLV-F10 carrying EOS-03 was launched from Sriharikota on August 12, 2021. The mission could not be accomplished as intended due to a technical anomaly.

Acronyms

AA	Aluminium Alloy
AAI	Airport Authority of India
ABPP	Air Breathing Propulsion Project
ACL	Antrix Corporation Limited
ADCOS	Advisory Committee for Space Sciences
ADRDE	Ariel Delivery Research and Development Establishment
AFC	Autonomous Film Cooling
AFTN	Aeronautical Fixed Telecommunication Network
AGEOS	Antarctica Ground Station for Earth Observation Satellites
AICTE	All India Council for Technical Education
AIT	Assembly, Integration and Testing
AMD	Atomic Minerals Directorate
AoI	Area of Interest
APEP	Ammonium Perchlorate Experimental Plant
ARG	Automatic Rain Gauge
ASDM	Aerial Services and Digital Mapping
ASIC	Application Specific Integrated Circuit
ASICs	Application Specific Integrated Circuits
ASTDC	Advanced Space Technology Development Cell
AVIRIS-NG	Airborne Visible Infrared Imaging Spectrometer-Next Generation
AWiFS	Advanced Wide Field Sensor
AWS	Automatic Weather Stations
BPOFM	Bunched Passage Orifice Flow Meter
BSX	Bengaluru Space Expo
CATVAC	Comprehensive Assembly and Test Vacuum Chamber
CCoE	Chief Controller of Explosives
CDMA	Code Division Multiple Access
CeNSE	Centre for Nano Science and Engineering
CEOS	Committee on Earth Observation Satellites
CES	Crew Escape System
CFRP	Composite Fiber Reinforced Plastic
CGMS	Coordination Group for Meteorological Satellites
CHAMAN	Coordinated programme on Horticulture Assessment & Management using Geoinformatics
CME	Continuing Medical Education
CMOS	Complementary Metal Oxide Semiconductor
CMS	Communication & Data Relay Satellite

CNES	Centre National d'Etudes Spatiales
COB	Chip-On-Board
CoE	Centre of Excellence
CORS	Continuously Operating Reference Stations
COSPAR	Committee on Space Research
CPCB	Central Pollution Control Board
CSA	Charge Sensitive Amplifier
CSSTE-AP	Centre for Space Science and Technology Education in Asia and the Pacific
CUS	Cryogenic Upper Stage
DAC&FW	Department of Agriculture, Cooperation & Farmers' Welfare
DECU	Development and Educational Communication Unit
DEM	Digital Elevation Model
DGCA	Directorate General of Civil Aviation
DMS	Disaster Management Support
DOHS	Directorate of Occupational Health and Safety
DoLR	Department of Land Resources
DOORS	Dynamic Object Oriented Requirements System
DOS	Department Of Space
DRT	Data Relay Transponder
DSN	Deep Space Network
DSNG	Digital Satellite News Gathering
DTH	Direct-to-home
DWR	Doppler Weather Radars
ECMWF	European Centre for Medium Range Weather Forecasts
ECVs	Essential Climate Variables
EGC	Engine Gimbal Control
EIA	Equatorial Ionization Anomaly
EIRP	Effective Isotropic Radiated Power
EMA	Electromechanical actuators
ENWi	Electron density and Neutral Wind
EO	Earth Observation
EOC	Early Operations Capability
EOS	Earth Observation Satellite
ESA	European Space Agency
ESIC	Employees State Insurance Corporation
EUMETSAT	European Organisation for Exploitation of Meteorological Satellites

FCC	False Colour Composite
FM	Flight Model
FSI	Forest Survey of India
FSS	Fixed Satellite Services
FTP	File Transfer Protocol
GAC	Global Area Coverage
GAGAN	GPS Aided Geo Augmented Navigation
GEO	Geostationary Earth Orbit
GeoMGNREGA	GIS Implementation of MGNREGA
GHRC	Geo High Resolution Camera
GHz	Giga Hertz
GIS	Geographical Information System
GISAT	Geo Imaging Satellites
GLOF	Glacial Lake Outburst Flood
GNSS	Global Navigation Satellite System
GOCO	Government Owned and Company Operate
GPP	Gross Primary Production
GPS	Global Positioning System
GSAT	Geosynchronous Satellite
GSI	Geological Survey of India
GSLV	Geosynchronous Satellite Launch Vehicle
GSLV MkIII	Geosynchronous Satellite Launch Vehicle Mark III
GTO	Geosynchronous Transfer Orbit
HAVA	Hypersonic Air Breathing Vehicle with Air frame integrated system
HEM	High-altitude Escape Motor
HMC	Hybrid Micro Circuit
HSP	Human Spaceflight Programme
HTS	High Throughput Satellite
HTVE	High Thrust Vikas Engine
HySIS	Hyper Spectral Image Sensor
IA	Implementing Arrangement
IAA	International Academy of Astronautic
IADC	Inter-Agency Space Debris Coordination Committee
IAF	International Astronautical Federation
ICC	INSAT Coordination Committee
ICD	Interface Control Document
ICG	International Committee for Global Navigation Satellite Systems

ICT	Information & Communication Technology
IDSN	Indian Deep Space Network
IGS	International Ground Stations
IIRS	Indian Institute of Remote Sensing
IISc	Indian Institute of Science
IISL	International Institute of Space Law
IISU	ISRO Inertial Systems Unit
IIT	Indian Institute of Technology
IITs	Indian Institute of Technologies
IMD	India Meteorological Department
IMDPS	INSAT Meteorological Data Processing System
IMPRINT	IMPacting Research Innovation and Technology
IMS	Indian Mini Satellite
INC	IRNSS Navigation Centre
INCOIS	Indian National Centre for Ocean Information Services
INCOSPAR	Indian National Committee for Space Research
INMCC	Indian Mission Control Centre
INSAT	Indian National Satellite
INSPACe	Indian National Space Promotion and Authorization Center
IPRC	ISRO Propulsion Complex
IRCDR	IRNSS CDMA Ranging Stations
IRDCN	IRNSS Data Communication Network
IRIMS	IRNSS Range & Integrity Monitoring Stations
IRNSS	Indian Regional Navigation Satellite System
IRNWT	IRNSS Network Timing Facility
IRS	Indian Remote Sensing
IRSCF	IRNSS Spacecraft Control Facility
ISECG	International Space Exploration Coordination Group
ISITE	ISRO Satellite Integration and Test Establishment
ISPRS	International Society for Photogrammetry and Remote Sensing
ISRO	Indian Space Research Organisation
ISTRAC	ISRO Telemetry, Tracking and Command Network
ITBP	Indo Tibetan Border Police
IWMP	Integrated Watershed Management Programme
JAXA	Japan Aerospace Exploration Agency
KSDMA	Kerala State Disaster Management Authority
LAC	Local Area Coverage

LCS	Lagrangian Coherent Structures
LEM	Low-altitude Escape Motor
LEO	Low Earth Orbit
LEOS	Laboratory for Electro-Optics Systems
LIN	Liquid Nitrogen
LIS	Land Information System
LISS	Linear Imaging Self-Scanning
IIST	Indian Institute of Space Science and Technology
LPSC	Liquid Propulsion Systems Centre
LST	Land Surface Temperature
LULC	Land Use / Land Cover
LUTs	Local User Terminals
LWIR	Long Wave Infrared
M&C	Monitor & Control
MADRAS	Microwave Analysis and Detection of Rain and Atmospheric Structures
MCF	Master Control Facility
MEMS	Micro-Electro-Mechanical Systems
MHRD	Ministry of Human Resource Development
MIDH	Mission for Integrated Development of Horticulture
MoD	Ministry of Defence
MODIS	Moderate Resolution Imaging Spectroradiometer
MOSDAC	Meteorological and Oceanographic Satellite Data Archival Centre
MoU	Memorandum of Understanding
MRCCs	Maritime Rescue Coordination Centres
MRD	Ministry of Rural Development
MSA	Mechanical Systems Area
MSS	Mobile Satellite Services
NARL	National Atmospheric Research Laboratory
NASA	National Aeronautics and Space Administration
NaVIC	Navigation with Indian Constellation
NDEM	National Database for Emergency Management
NDVI	Normalised Difference Vegetation Index
NEC	North Eastern Council
NEE	Net Ecosystem Carbon Exchange
NER	North Eastern Region
NE-SAC	North Eastern-Space Applications Centre
NGOs	Non-Government Organisations

NGPE	Non-Government Private Entity
NHP	National Hydrology Project
NICES	National Information System for Climate and Environment Studies
NISAR	NASA-ISRO Synthetic Aperture Radar
NOAA	National Oceanic and Atmospheric Administration
NPLI	National Physical Laboratory India
NRSC	National Remote Sensing Centre
NSIL	NewSpace India Limited
NSSO	National Sample Survey Office
NTU	Nanyang Technical University
NWH	North West Himalaya
OBC	On-Board computer
OCM	Ocean Colour Monitor
ORV	Orbital Re-entry Vehicle
PAT	Pad Abort Test flight
PC-NNRMS	Planning Committee on National Natural Resources Management System
PRL	Physical Research Laboratory
PSLV	Polar Satellite Launch Vehicle
R&D	Research & Development
RAPID	Real Time Analysis Product & Information Dissemination
RCCs	Rescue Coordination Centres
RCS	Reaction Control System
RCT	Reaction Control Thrusters
RDAS	Reconfigurable Data Acquisition System
RESPOND	Research Sponsored
RIS	RLV Interface System
RISAT	Radar of India's Radar Imaging Satellite
RLV-TD	Reusable Launch Vehicle
RN	Radio Networking
ROSA	Radio Occultation Sounder for Atmospheric studies
ROSCOSMOS	Russian Federal Space Agency
ROTs	Receive Only Terminals
RRSCs	Regional Remote Sensing Centres
RS	Restricted Service
SAARC	South Asian Association for Regional Cooperation
SAC	Space Applications Centre

SANSA	South African National Space Agency
SAPHIR	Sounder for Probing Vertical Profiles of Humidity
SAR	Synthetic Aperture Radar
SARAL	Satellite with ARGOS and ALTIKA
SAS & R	Satellite Aided Search and Rescue
SATNAV	Satellite Navigation
SBAS	Satellite Based Augmentation System
SCENC	Semi Cryo Engine Nozzle Closure
SCL	Semi-Conductor Laboratory
SCORPIO	Satellite Based Cyclone Observation for Real-time Prediction over Indian Ocean
SDSC	Satish Dhawan Space Centre
SIS	Signal-In-Space
SITs	Satellite Interactive Terminals
SPADEX	Space Docking Experiment
SPPU	Savitribai Phule Pune University
SPROB	Solid Propellant Space Booster Plant
SPS	Standard Positioning Service
SSC	Swedish Space Centre
SSPA	Solid State Power Amplifier
SST	Sea Surface Temperature
SSTL	Surrey Satellite Technology Limited
SSTM	Sea Surface Temperature Monitor
SSV	Space Service Volume
STC	Space Technology Cells
SVAB	Second Vehicle Assembly Building
SWIR	Short Wave Infrared
TDP	Technology Development Programmes
TDV	Technology Demonstrator Vehicle
TERLS	Thumba Equatorial Rocket Launching Station
TG	Temperature-Greenness
TMA	Trimethyl Aluminum Experiment
TSTO	Two-Stage-to-Orbit
TT&C	Telemetry & Commanding
TTC	Telemetry and Telecommand
TV	Television
TWRIS	Telangana Water Resources Information System

UAE	Ukraine, United Arab Emirates
UAY	Uchchatar Avishkar Yojana
UFA	Unfurlable Antenna
UFS	Urban Frame Survey
UK	United Kingdom
ULBs	Urban Local Bodies
UN	United Nations
UNISPACE	United Nations Conference on the Exploration and Peaceful Uses of Outer Space
UNNATI	Unispace Nanosatellite Assembly &Training
URSC	U R Rao Satellite Centre
USA	United States of America
USGS	United States Geological Survey
VEDAS	Visualization of Earth observation Data and Archival System
VHRS	Very High Resolution Satellite
VLSIs	Very Large Scale Integrated Circuits
VNIR	Very Near Infra Red
VSAT	Very Small Aperture Terminal
VSSC	Vikram Sarabhai Space Centre
VTM	Velocity Trimming Module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