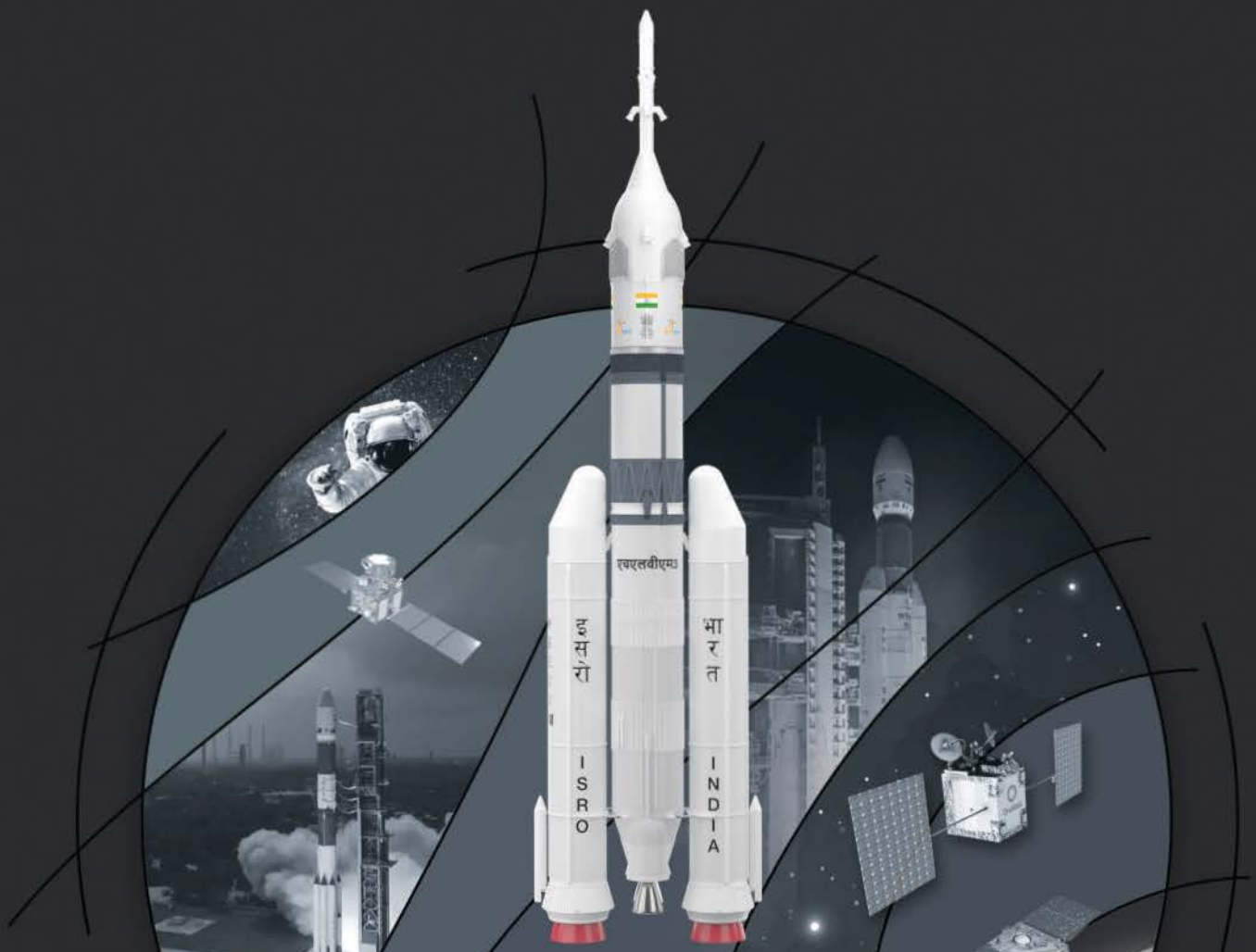
भारत सरकार
अंतरिक्ष विभाग

सत्यमेव जयते

GOVERNMENT OF INDIA
DEPARTMENT OF SPACE



वार्षिक रिपोर्ट
ANNUAL REPORT
2022-2023

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Space Missions
(As per Financial Year)

Mission	2021-22	2022-23	2023-24
Earth Observation Satellites	2	3*	2
Communication Satellites	0	0	1
Navigation Satellites	0	0	1
Space Science Satellites	0	0	3
Technology Demonstrator	0	0	0
PSLV	1	2	4
GSLV	1	0	2
LVM3	0	2*	1
Small Satellite Launch Vehicle	0	2*	1
Gaganyaan	0	0	0
TOTAL	4	9	15

*Including the missions expected to be achieved by March 2023

01

Organisation Chart

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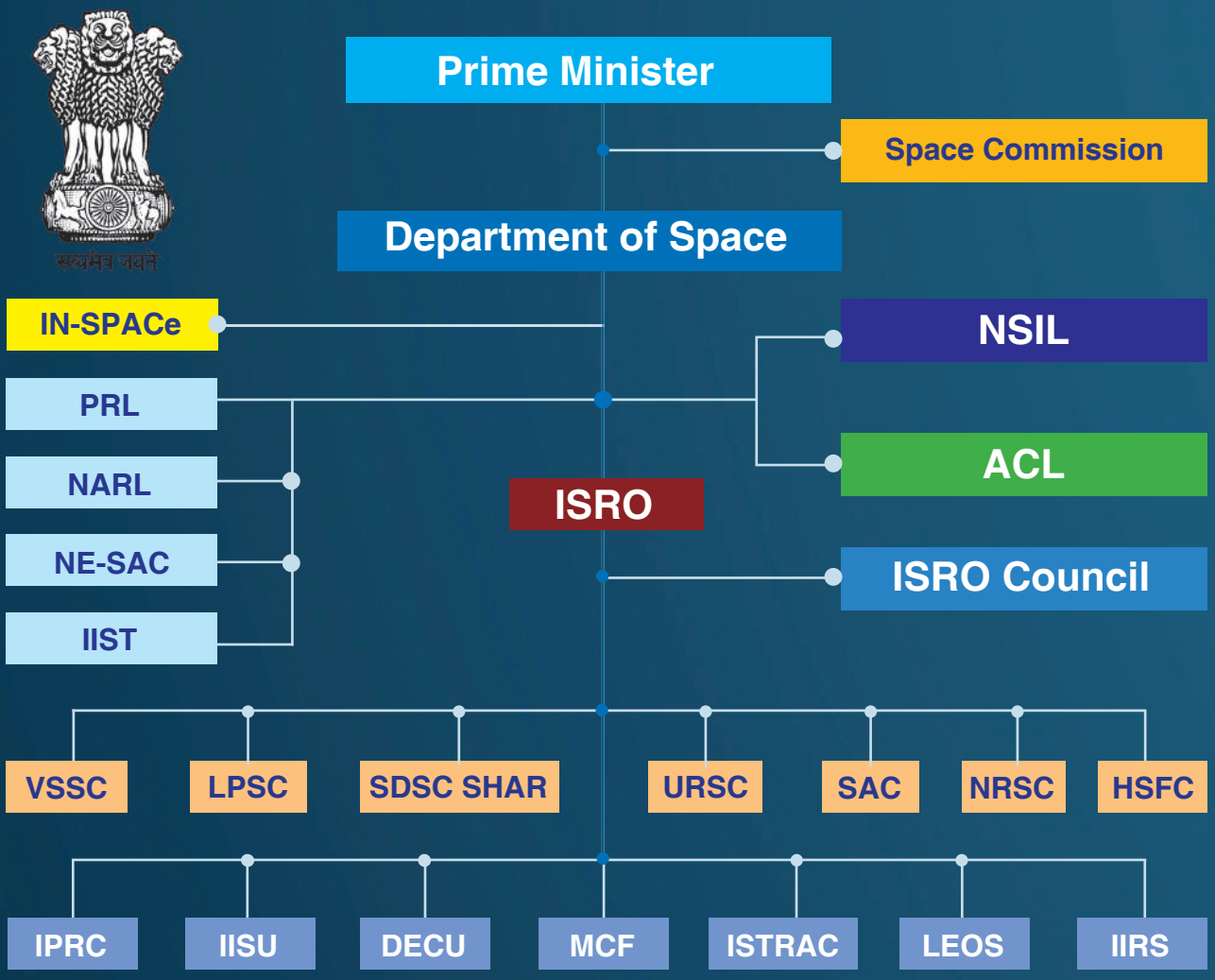


ACL	Antrix Corporation Limited
DECU	Development and Educational Communication Unit
HSFC	Human Space Flight Centre
IIRS	Indian Institute of Remote Sensing
IIST	Indian Institute of Space Science and Technology
IISU	ISRO Inertial Systems Unit
IN-SPACe	Indian National Space Promotion and Authorization Center
IPRC	ISRO Propulsion Complex
ISRO	Indian Space Research Organisation
ISTRAC	ISRO Telemetry, Tracking and Command Network
LEOS	Laboratory for Electro Optics Systems
LPSC	Liquid Propulsion Systems Centre
MCF	Master Control Facility
NARL	National Atmospheric Research Laboratory
NE-SAC	North Eastern Space Applications Centre
NRSC	National Remote Sensing Centre
NSIL	NewSpace India Limited
PRL	Physical Research Laboratory
SAC	Space Applications Centre
SDSC SHAR	Satish Dhawan Space Centre Sriharikota High Altitude Range
URSC	U R Rao Satellite Centre
VSSC	Vikram Sarabhai Space Centre

Space Centres in India

JODHPUR
- Western RRSC

UDAIPUR
- Solar Observatory

AHMEDABAD
- Space Applications Centre
- Physical Research Laboratory
- Development and Educational Communication Unit
- Indian National Space Promotion and Authorization Centre (IN-SPACe)

Mt. ABU
- Infrared Observatory

NEW DELHI
- DOS Branch Secretariat
- ISRO Branch Office
- Delhi Earth Station
- Northern RRSC

DEHRADUN
- Indian Institute of Remote Sensing
- Centre for Space Science and Technology Education in Asia-Pacific

SHILLONG
- North Eastern-Space Applications Centre

LUCKNOW
- ISTRAC Ground Station
- ISRO Navigation Centre

KOLKATA
- Eastern RRSC

NAGPUR
- Central RRSC

MUMBAI
- ISRO Liaison Office

BHOPAL
- Master Control Facility - B

HYDERABAD
- National Remote Sensing Centre

BENGALURU
- Space Commission
- Department of Space and ISRO Headquarters
- NNRMS Secretariat
- Antrix Corporation
- NewSpace India Limited
- U R Rao Satellite Centre
- Human Space Flight Centre
- Laboratory for Electro-Optic Systems
- ISRO Telemetry, Tracking and Command Network
- Southern RRSC
- Liquid Propulsion Systems Centre

SRIHARIKOTA
- Satish Dhawan Space Centre, SHAR

TIRUPATI
- National Atmospheric Research Laboratory

ALUVA
- Ammonium Perchlorate Experimental Plant

PORT BLAIR
- Down Range Station

HASSAN
- Master Control Facility

BYALALU
- Indian Deep Space Network
- Indian Space Science Data Centre
- ISRO Navigation Centre

MAHENDRAGIRI
- ISRO Propulsion Complex

THIRUVANANTHAPURAM
- Vikram Sarabhai Space Centre
- Liquid Propulsion Systems Centre
- ISRO Inertial Systems Unit
- Indian Institute of Space Science and Technology

Space activities in the country were launched with the setting up of the 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), and North Eastern-Space Applications Centre (NE-SAC). Antrix Corporation Ltd. and NewSpace India Limited are the two Central Public Sector Enterprises 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, systems reliability and quality, safety, budget and economic analysis, human resources and capacity building & public outreach. The major establishments of DOS and their area of activities are given in the following paragraphs.

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), Launch Vehicle Mark-3 (LVM3) , 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.

VSSC Main Building at Veli Range Complex

URSC

U R Rao Satellite Centre (URSC)

URSC, Bengaluru is the lead Centre for design, development, and the realisation of communication, navigation, remote sensing, scientific and small satellite missions. The specialized teams of scientists, engineers, and technicians of URSC have built 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.

ISRO Satellite Integration and Test Establishment (ISITE), established in 2006, is equipped with facilities for the complete assembly and test sequence that can enable the 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.

URSC Main Building

Satish Dhawan Space Centre (SDSC) SHAR

SDSC

Satish Dhawan Space Centre (SDSC) SHAR

SDSC 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 a timely supply of production deliverables and precise accomplishment of activities to match the varying needs of ISRO's Launch Vehicle and Satellite communities and also the Indian and foreign customers.

LPSC

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's launch vehicles and satellites.

LPSC activities and facilities are spread across its two campuses, namely, LPSC, Valiamala, Thiruvananthapuram, and LPSC, Bengaluru. The activities on its campus at Valiamala include design and development entities for earth-storable, cryogenic, semi-cryogenic, and electric propulsion systems. The end-to-end design, development, and realisation of flow control components and modules, advanced manufacturing and proto fabrication, as well as R&D activities in the area of propulsion and structure are carried out by expert entities. LPSC activities in its campus in 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 & sensors are undertaken here.

LPSC (Bengaluru)

LPSC (Valiamala)


SAC Main Campus


SAC New Bhopal Campus


SAC Bhopal Technical Campus


Delhi Earth Station

SAC

Space Applications Centre (SAC)

SAC, Ahmedabad, 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 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.

HSFC

Human Space Flight Centre (HSFC)

HSFC was formed in 2019, as a lead Centre for human space flight activities. HSFC undertakes 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 from ISRO-HQ campus, Bengaluru. Apart from Gaganyaan, HSFC will focus in the future on new areas of technology development, significant amongst them being 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)

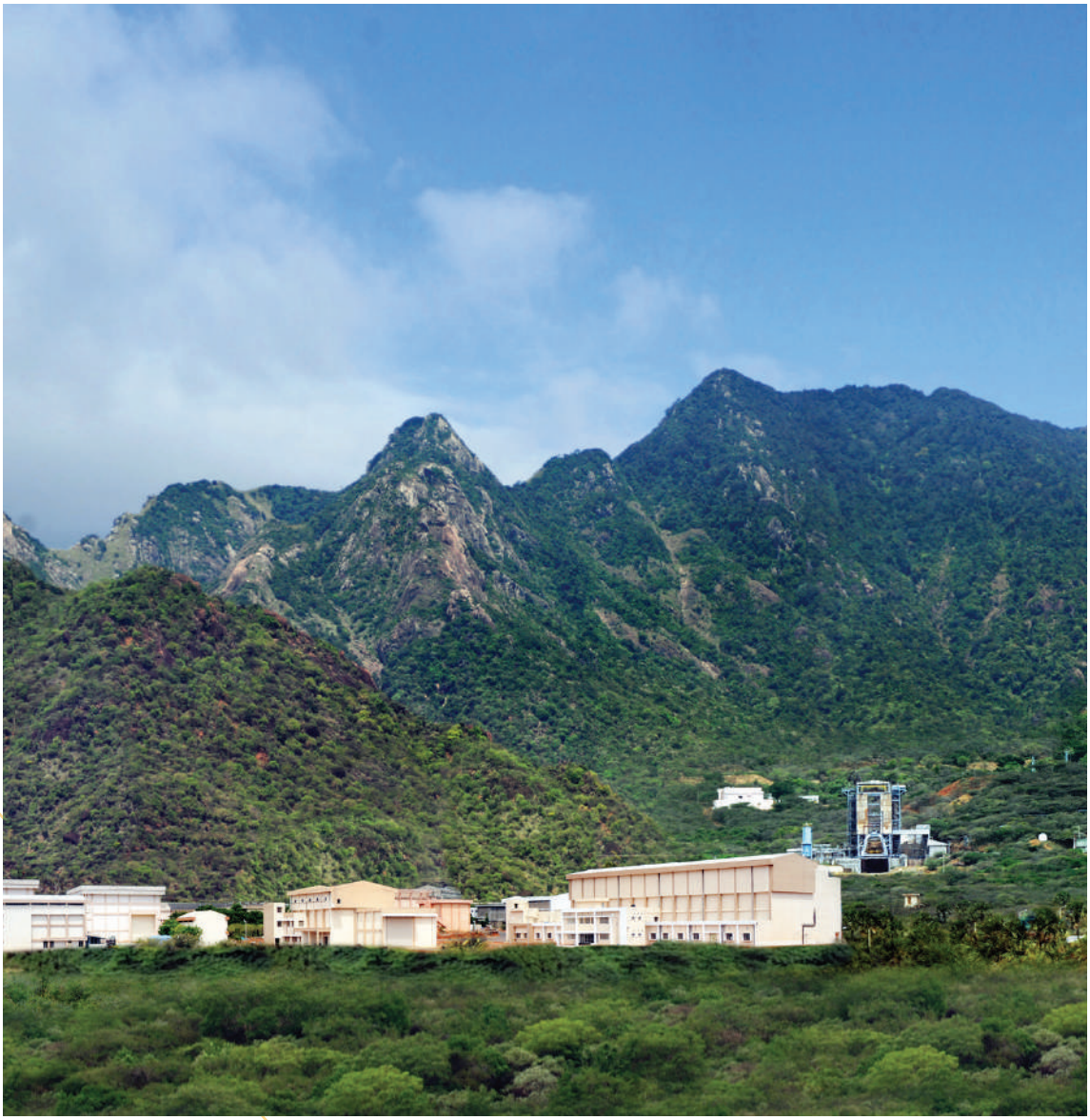
NRSC has the mandate for the establishment of ground stations for receiving satellite data, generation of data products, aerial remote sensing data acquisition, dissemination to the users, development of techniques for remote sensing applications including disaster management support, geospatial services 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 and Bhoonidhi are the geoportals of NRSC for the dissemination of satellite data and geospatial products and services in the country. Outreach facility at Jeedimetla in Hyderabad provides training for professionals, faculty, and students and for general outreach. The aircraft operations facility is at Begumpet Airport, Hyderabad.

IPRC

ISRO Propulsion Complex (IPRC)

IPRC, Mahendragiri is responsible for the 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 provides a platform for simulation trials for interplanetary missions. IPRC is equipped with state-of-the-art facilities necessary for realising cutting-edge technology products for ISRO's space program.



ISTRAC

ISRO Telemetry, Tracking and Command Network (ISTRAC)

ISTRAC, is entrusted with the primary responsibility of providing TTC and mission control services to major Launch Vehicle, 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, and tele-education.

In order to realisae these objectives, ISTRAC has established a network of ground stations, five stations at Bengaluru, three 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).

MCF

Master Control Facility (MCF)

MCF is responsible for On-Orbit Operations (OOP) and Launch & Early Orbit Phase (LEOP) operations of geostationary/ geosynchronous & IRNSS class of spacecrafts 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 GEOSAT and IRNSS class spacecrafts with payloads classified into communication, meteorological & navigational categories. These satellites are placed between 32.50° E & 129.50° E 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, and 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.

IISU is engaged in continuous Research and Development. IISU has initiated advanced technology development programmes in niche areas focusing on miniaturisation, low power & 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 spacecraft. 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 breakdown spectroscopy (LIBS), MEMS Seismometer, and specialized optics for payloads of Aditya–L1 (VELC and SUIT).

IIRS

Indian Institute of Remote Sensing (IIRS)

IIRS, Dehradun, 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. 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, 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 policymakers including academia, industry, and NGOs.

DECU

Development and Educational Communication Unit (DECU)

Established in 1983, DECU, located in Ahmedabad, has been the focal unit of ISRO for the 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 the 'last mile' in space applications. The unit has been responsible for the conceptualisation and demonstration of many societal applications of satellite communications.

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 & 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.

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

NE-SAC

North Eastern-Space Applications Centre (NE-SAC)

NE-SAC 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. The Centre has provided more than two decades of dedicated service for the holistic development of the NER of India.

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 with its corporate office in Bengaluru is a wholly-owned Government of India company under the administrative control of DOS. Antrix is engaged in providing Space sector products and services worldwide ranging from supply of hardware and software, earth observation and scientific missions, remote sensing data services, transponder lease services, launch services, mission support services, and other allied services.

NSIL

NewSpace India Limited (NSIL)

NSIL got incorporated in 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 (vi) 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 the rolling out of space-based services and all the associated infrastructure for the same. IN-SPACe operates with its headquarters in Ahmedabad and field offices in Bengaluru and Mumbai.

02

Major Activities

2.1 Earth Observation, Data Processing, and Applications

Satellite Data Reception

Satellite Data Reception: The prime objective of Satellite Data Reception and Ingest Systems is to receive and archive the payload data from different Indian and foreign remote sensing satellites to meet the Indian systematic coverage and global data requirements of the user community. Remote Sensing Data from foreign satellites are also being received, processed & archived regularly. The numbers of Indian and foreign missions supported are 18 and 8, respectively, acquiring around 25947 passes during the year 2022, meeting > 99.9 % station efficiency.

IMGEOS: Integrated Multi-Mission Ground Segment for Earth Observation Satellites (IMGEOS) established at Shadnagar acquires data from various Indian Remote Sensing satellites and foreign satellites. In 2022, the station was augmented with one 7.5M S/X antenna with tri-axis to handle zenith passes as well as five mission clashes.

AGEOS: "Antarctica Ground Station for Earth Observation Satellites (AGEOS)" facility was established by ISRO in 2013 at Bharati (Research base of NCAOR), Antarctica. The station has two antenna systems one dual-band (S/X) and one tri-band antenna (S/X/Ka). The data received from various Remote Sensing Satellites is transferred through high-speed communication links to NRSC in near real-time. The Station is also supporting the Launch and Early Orbit Phase (LEOP) operations of PSLV.

Antenna System Establishment and Upgradation

Ground station at Bhutan for INS-2B satellite: Installation and commissioning of the Antenna system with Antenna Control Servo System (ACSS) and ingest system completed for data reception from INS-2B at the Department of Information Technology and Telecom (DITT), Bhutan. Real-time data acquisition from the INS-2B satellite was carried out successfully from December 07, 2022.

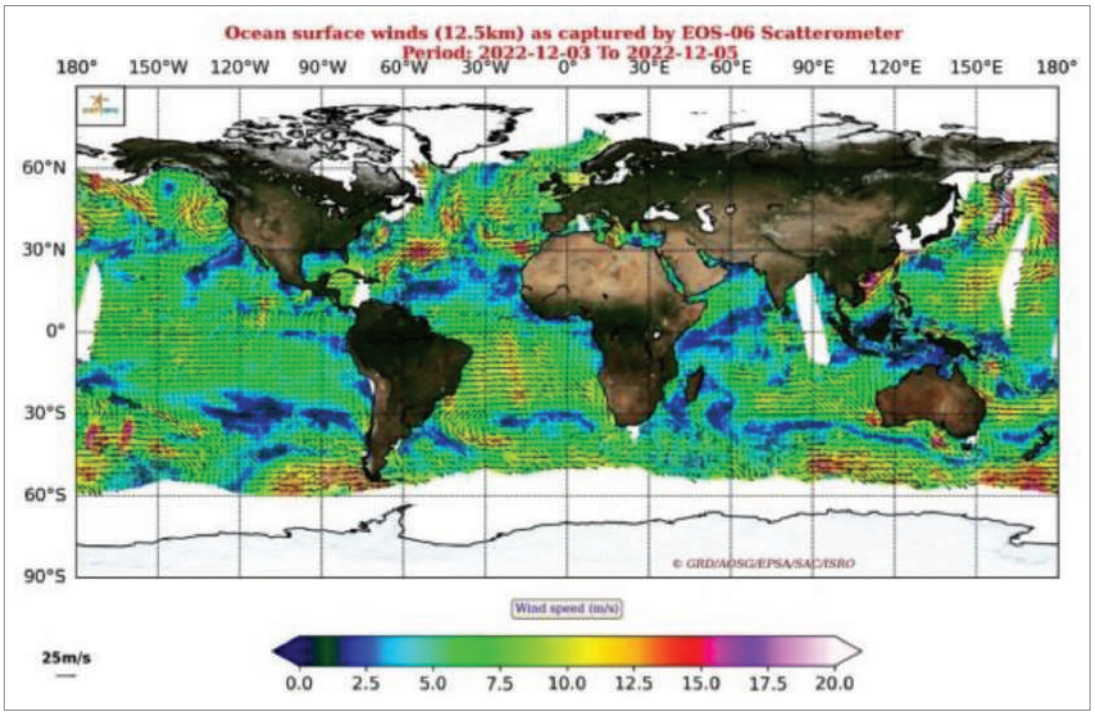
Second 7.3 m S/Ka Band antenna at IMGEOS, Shadnagar: Second S/Ka band Data Reception Antenna system is made operational to support Ka-band data reception from Cartosat-3 with Quadrature Phase Shift Keying (QPSK)/8PSK modulation with 2.88 Gbps data rate.

7.5m S/X band Ground Station Upgrade at INCOIS: The upgradation was carried out through in-house development of ACSS Software/ Hardware, including Antenna control & Drive units, and operationalized at INCOIS.

Tri-Axis Antenna System at IMGEOS: The first Tri-axis 7.5m S/X band Antenna System with in-house developed GUI application software in IMGEOS has been established to overcome the cone of silence issue of traditional two-axis Antennas. Tri-Axis ACSS software was developed and customized at IMGEOS Ground Station.

Data Processing, Products, Archival, and Web Applications

Data products were generated using standard product and interactive product generation chains 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.



EOS-06 Scatterometer First Global Wind Estimation

2.1 Earth Observation, Data Processing and Applications

EOS-04 products are announced to users. For all the acquisitions, Level-2 products were generated and cataloged in the Bhoonidhi portal, and products are being disseminated to users for various applications in Agriculture, Forestry, Oceanography, and Disaster management support. Global Archival data has also been collected in CRS mode. EOS-06 products are planned for dissemination after calibration and validation.

A number of optical and microwave sensor data sets were processed and archived. Value-added data products were generated to support national flagship applications programmes as well as catering project-based data requirements.

Satellite Data Dissemination: A total of 1,23,590 products were disseminated to users. High and medium-resolution data, of 54,023 sq. km pertaining to foreign satellites, was also disseminated to users. As per the new procedure for Foreign Satellite Data Procurement, the authorisation certificates were issued to users for procuring the data of 50,18,767 sq. km.

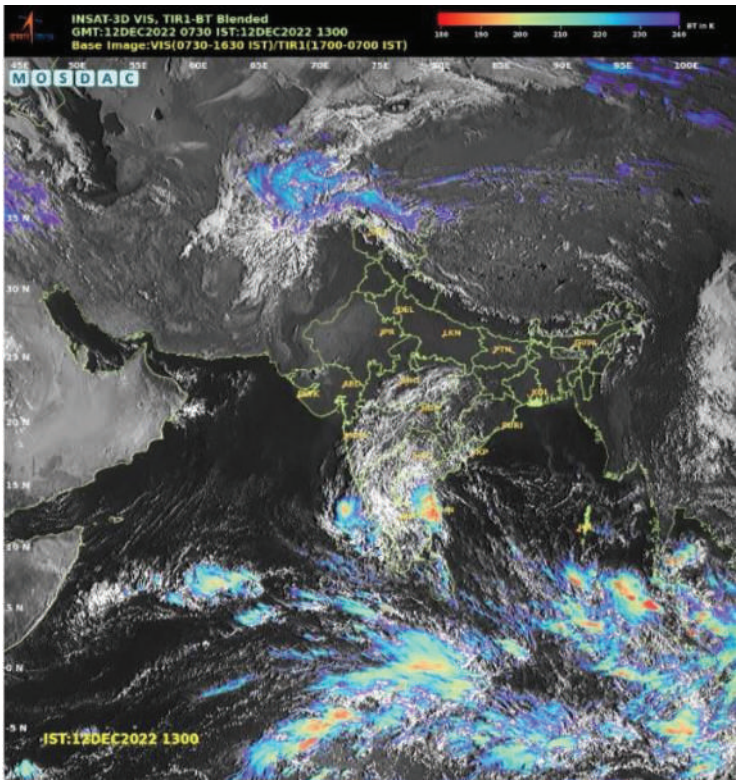
Bhoonidhi Vista Portal

Bhoonidhi Vista (Visualization of terrestrial acquisitions) is updated with additional facilities to integrate the satellite data of EOS-04 and is planned for EOS-06. Bhoonidhi Vista showcases how India looked in the recent past with Indian and other EO sensors in native resolution at various zoom levels. It is first-hand visual insights in various spectral and spatial resolutions suitable for applications requiring fast response like monitoring, viewing affected /impacted areas of floods, cyclones, and other disasters, and how India looked in the past few hours or days.

MOSDAC and VEDAS Portals Meteorological and Oceanographic Satellite Data Archival Centre (MOSDAC) is providing near real-time satellite data to operational agencies within the country like the National Centre for Medium-Range Weather Forecasting (NCMRWF), India Meteorological Department (IMD), Indian Navy, Ministry of Renewable Energy, Mahalanobis National Crop Forecast Centre (MNCFC) as well as international users like NASA/NOAA, EUMETSAT, and CNES. Seasonal Forecast of Indian Summer Monsoon (ISM) 2022 using Ensemble Global Atmosphere Model CAM was released on MOSDAC. Automated dissemination of WRF forecast provided for Bihar Mausam Seva Kendra (BMSK). Integrated Village Level Zonal Statistics (AWiFS and Sentinel2 NDVI) for IMD was completed and demonstrated.

A suitable framework for the operationalization of the Agri-Decision Support

System (DSS) is being developed on the Visualization of Earth Observation Data and Archival System (VEDAS) platform. In this regard, an MOU was signed between the Department of Space (DOS) and the Department of Agriculture and Farmer's Welfare (DAFW).

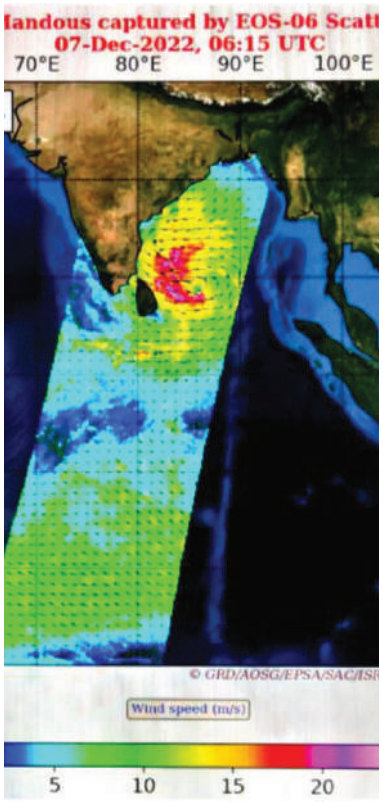


INSAT-3D: VIS+TIR blended product

Bhuvan Geoportal and Web Services

Web and Mobile applications/ services:

The new services added are **WBIS 2.0** - for monthly and fortnight water spread information, integrated monthly Water Quality indices like Normalized Difference Chlorophyll Index (NDCI) and Normalized Difference Turbidity Index (NDTI); **Urban Water body information system** - Rejuvenation of water bodies in urban areas, min-max water spread area, water availability with different % of water spread area criteria. **Minor Irrigation** - Visualization of Minor Irrigation tanks of PAN India – Spatial query analysis of 16,10,395 Minor irrigation projects under Jal Shakti. **Aadhaar Seva Kendras** on Bhuvan across India - Citizen-centric application - addressing the location of different types of Aadhar centres.



Methodological frameworks, algorithms, software systems, calibration & validation activities and operationalizing the software in the respective ground stations and processing centers for Earth

2.1 Earth Observation, Data Processing and Applications

& Planetary Observation systems are undertaken at SAC. These include recently launched satellites viz., EOS-04 (RISAT-1A) EOS-06 (Oceansat-3), Bhutansat (INS-2B) etc.

Wind estimation comparison of the image obtained from the Scatterometer with ECMWF is made, and it is closely matched with the model. Ocean surface winds was observed over Tropical Cyclone Mandous during December 6-8, 2022 by EOS-06 Scatterometer.

Multi-Mission Data Receiving and Processing System (MMDRPS): INSAT-3D/ 3DR data processing chains were upgraded, and the new software has been operationalized at IMD.

Aerial Services and Digital Mapping: NRSC provided precise trajectory and attitude information to assess the performance of onboard sensors as part of the Integrated Hot Testing phase during Chandrayaan-3 lander sensors testing. Using UAV and RGB Digital camera a high-resolution Digital Elevation Model (DEM) of the Aeronautical Test Range (ATR), Chitradurga, has been generated for an area of 7.5 km x 1 km as part of the Reusable Launch Vehicle (RLV) Project.

LIDAR Survey: Airborne LiDAR survey over part of Kosi Basin is completed through outsourcing for Flood Management Improvement Support Centre (FMISC), Government of Bihar. Airborne LiDAR data is acquired for 2000 sq.km over Nayagarh and Simlipal areas for inventory design and imputation of stand/ structure description. Digital Terrain Model and Canopy Height Model of the Simlipal area have been genereated and delivered to FMISC.

Remote Sensing Applications

Agricultural Applications: A web-enabled geospatial crop monitoring system is developed incorporating satellite, weather, and mobile collected datasets for decision-making in crop insurance sectors. Progression of crop sowing & harvesting, cropping intensity, and technology-based yield estimation of soybean, cotton, and paddy were carried out over Maharashtra as part of the MahaAGRITECH project. Satellite and weather data products were generated at the fortnightly interval to assess the drought situation in eastern India towards supporting the National Crop Weather Watch group of MoA&FW, Government of India.

Under SUFALAM (Space technology Utilisation for Food security AgricuLtural Assessment and Monitoring), seven daily agro-met products are being generated for

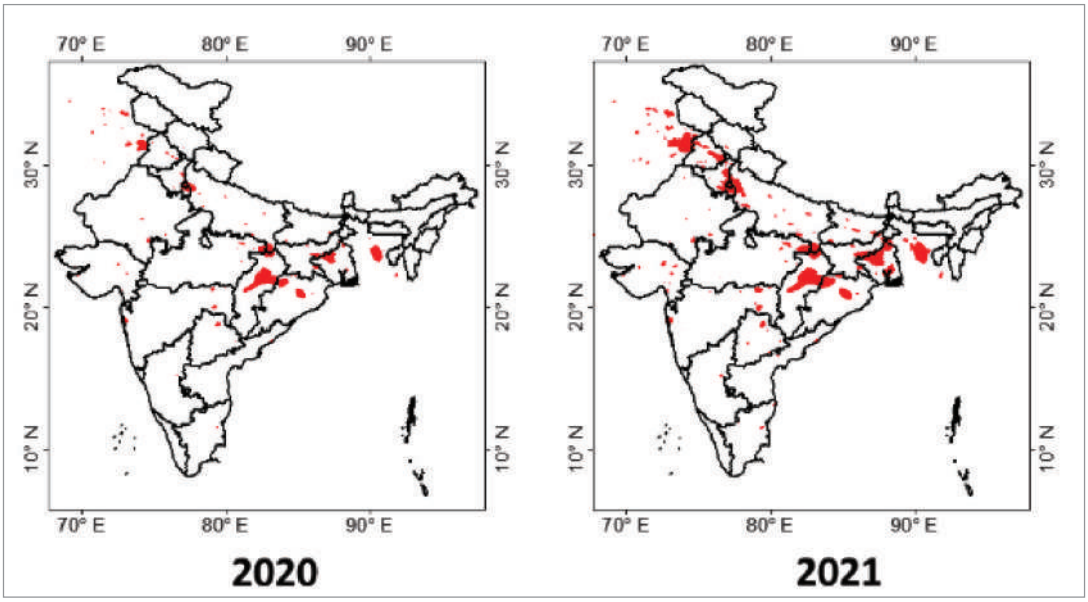
dissemination to six Agro-Met Field Units (AMFUs) in GKMS (Gramin Krishi Mausam Seva) Network of IMD (Agrimet), Ministry of Earth Sciences (MoES). Estimation of summer fodder crop area for the year 2022 was jointly carried out by SAC and AMUL, over the Mahisagar, Kheda, and Anand Districts of Gujarat using satellite data.

Water Resources Applications: Under the National Hydrology Project, NRSC is generating near real-time daily Actual Evapotranspiration (AET) for India at spatial resolutions of 5.5 km and 750 m using satellite observations. Ten (10) Eddy Covariance Flux Towers have been established under various agroecosystems across the country to validate ET products. A dashboard has been created in the Bhuvan-NHP ET Geo-portal to display the near real-time flux tower data https://bhuvan.nrsc.gov.in/nhp/webgis-et/map.

An Atlas was prepared on an inventory of glacial lakes (size >0.25ha) for the Brahmaputra river basin using Resourcesat-2 LISS-IV multispectral data.

Forestry & Ecology Applications: As part of operational forest fire activity, automated procedures to identify continuing fire activity around a location (long duration fire event - LDFE) were developed. This outcome is to be integrated with the NDEM portal. An automated approach to provide multispectral image-based forest fire-affected area estimates at LDFE locations has been demonstrated.

Environmental Applications: Under the project on **Biodiversity Characterisation**



Hotspots identified based upon a threshold from yearly averaged atmospheric NO_2 observed from satellite

2.1 Earth Observation, Data Processing and Applications

at Community Level in India, tree communities were mapped, decadal land cover changes were characterised, and fire hotspots analysis was carried out using satellite data. Landscape analysis of forest fragmentation and connectivity has been carried out using morphological spatial pattern tools.

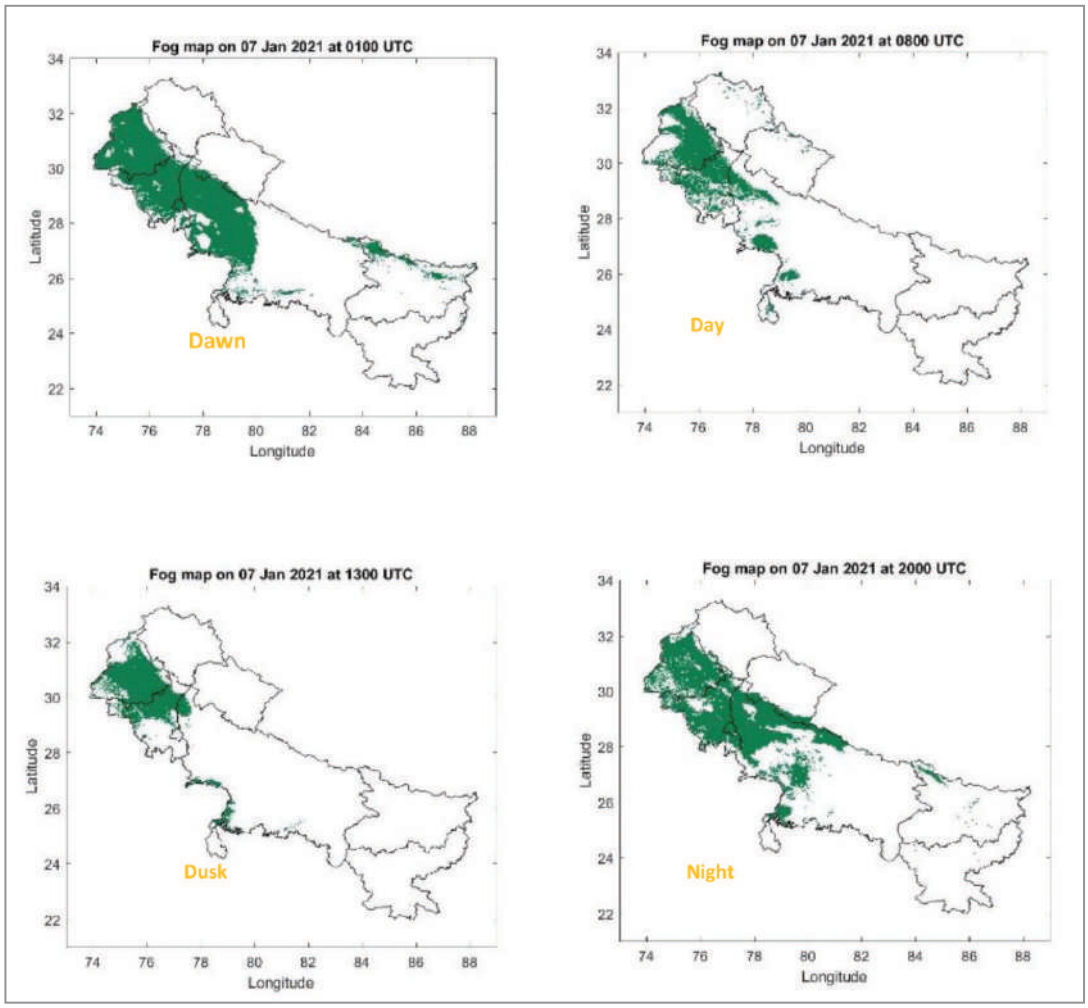
A scientific study to detect hotspots of **air pollution** over India has been carried out using space-borne data. A number of images of major pollutant gases such as NO_2, SO_2, and O_3 were processed from the TROPOMI sensor for obtaining a yearly average map for a four-year time period (2018 to 2021) as well as monthly mean images over India to map the hotspots.

Geoscience research and applications: A study was conducted for Hydrocarbon Exploration in the Northern part of Cambay Basin, Gujarat using multi-sensor, multi-parametric satellite and airborne data. An isopach map was used to delineate the thickness of reservoir rock, which is indicative of the favorable conditions for near-surface hydrocarbon accumulation. Geomorphic, lineaments, and spectral anomalies were used as a guide for identifying the potential areas for hydrocarbon exploration supplemented by field and ancillary data of the reservoir. The importance of each of the anomalies as the proxy for hydrocarbon accumulation was established from the geological knowledge of oil trap formation and the spatial relation of these themes with the anomalous concentration values derived from the adsorbed gas anomaly map. Subsequently, the weightage summation method was used to derive the potential map for hydrocarbon exploration.

Oceanographic Applications: An advanced Potential Fishing Zone (PFZ) advisory algorithm has been developed using multiple satellite observations such as Sea Surface Temperature (SST), chlorophyll, SLA, ocean surface wind, and currents data at SAC. This new method has an advantage during cloudy days as it provides information on wind and current based features movement, which was challenging to obtain from only chlorophyll and SST information.

Atmospheric Applications: INSAT-3D/3R Cloud Microphysical Product (both land and ocean) was operationalized at IMD, and nowcasting validation software has been installed at the IMD server. Validation of OCM-2 AOD aerosol product using in-situ data over 15 sites and OCM-2 product for the period 2016-2018 has been carried out. Overall performance of OCM-2 AOD products compared against in-situ AOD measured by AERONET stations show that OCM-2 AOD at high resolution (0.007 degrees) with high accuracy can be utilised for air quality applications, especially over metro cities.

The algorithm has been developed using SEVIRI (Spinning Enhanced Visible and



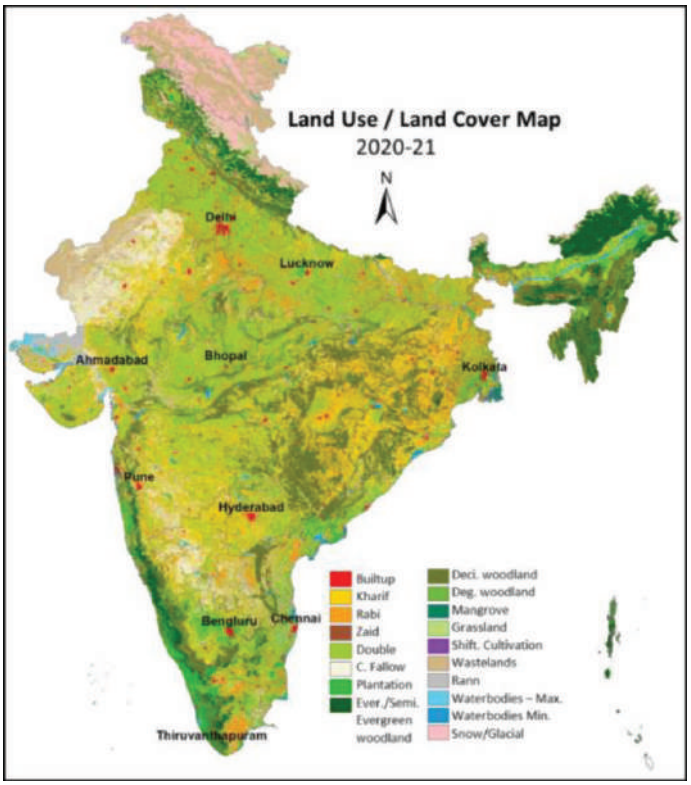
Fog images retrieved during Dawn, Day, Dusk and Night Time on January 7, 2021

Infrared Imager) data on board MSG (Meteosat second generation) satellite and ground visibility data. The algorithm can detect fog irrespective of time i.e., day, night, dawn, and dusk, with high accuracy. Figure above shows typical fog images retrieved during dawn, day, dusk, and night on January 7, 2021.

Land Resources Applications: Under the Natural Resources Census program 15th cycle (2020-21) of the Land Use / Land Cover (LULC) database was created using IRS AWiFS data at 1:250k for the entire country. Season-wise cropped area under Kharif, Rabi and monthly cropped area for August, September, December, and February (2020-21) were also prepared. Analysis showed that there was an increase in cropped area under Kharif and Rabi as compared to the 14th cycle (2019-20). Areas under Built-up were also increased during the above time frames.

Watershed interventions and resultant changes with respect to soil and water

2.1 Earth Observation, Data Processing and Applications



Land use/ Land cover map (2020-21)

conservation activities for a number of watershed project areas (6600 projects) were monitored using satellite data over five years.

Urban Water Bodies Inventory: 'Urban Water body Information System (UWaIS)' is being developed at the Bhuvan web portal for about 500 AMRUT (Atal Mission for Rejuvenation and Urban Transformation) cities for the Ministry of Housing and Urban Affairs (MoHUA, GoI). In order to carry out an inventory of waterbodies for each town, information pertaining to land use/land cover change analysis for two time periods (2010 and 2020), water quality details, location details, water sustenance over the years, time series water spread area etc., have been organized on the web-portal platform. It would be a single-point destination for comprehensive information about a water body in an urban area.

Disaster Management Support (DMS)

Floods: 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 14 states. Major floods occurred in Assam, Bihar, Uttar Pradesh, Odisha, Andhra

Pradesh, and Telangana States. About 247 flood inundation maps and value-added products were prepared and disseminated to Central and State DMS Organisations in near real-time. Flood Hazard Zonation Atlases were prepared for Uttar Pradesh, Andhra Pradesh & West Bengal and were using historical satellite data in association with National Disaster Management Authority (NDMA). Studies on River Bank Erosion & Deposition in the Brahmaputra & Kosi rivers were conducted using temporal remote sensing data. Results were sent to the concerned organisations. Web enabled real-time spatial flood forecast system models were run in real-time during the year 2022 (June to October), and flood alerts were disseminated through Bhuvan.

International Commitments: During 2022, NRSC responded to 13 disaster events in 8 countries with the help of 26 IRS satellite datasets.

Landslides in Assam: Dima Hasao district of Assam encountered rainfall-triggered floods, and landslides across the district, with the Haflong town and railway station were severely affected during May 12-17, 2022. Further major roads connecting villages and towns in and around Haflong were disconnected due to landslides. Damage assessment of the region was carried out using high-resolution optical satellite imagery from Resourcesat 2A (resolution: 5.8m), Sentinel-2 (10 m), and Cartosat 3 (1.1m) satellite data. A total of 5,178 landslides were mapped in the Dima Hasao district using multi-temporal cloud-free satellite data. The New Haflong station had suffered maximum damage due to debris flows from the adjacent slopes on either side.

2.2 Space Applications

Satellite Communication Applications

A fleet of 18 communication satellites is operating over India with communication transponders in C-band, Extended C-band, Ku-band, Ka/Ku band, and S-band. Out of these, 11 satellites are owned and operated by NSIL. These satellites together provide 317 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, strategic communication, and societal applications. The prominent users of the transponders are Government & Strategic users, Prasar Bharati, DTH and TV operators, Public sector units (BSNL, ONGC, AAI, ECIL etc.), private VSAT operators, banking and financial institutions, etc.

DOS/ISRO has continued supporting societal programmes like Telemedicine, 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 society.

To meet additional transponder requirements from various user sectors, about 70 transponders in Ku-Band and HTS capacity of 1.6 GHz were 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 television sector.

Doordarshan is presently operating 36 satellite channels and has a vast network of Studios throughout the length and breadth of the country and terrestrial Transmitters of varying power in strategic areas. DD has 41 C-band Earth Stations for program contribution & distribution of DD Channels and one C-Band DTH Earth Station for providing DTH service to Andaman and Nicobar Island where Ku-Band DTH footprints are not available. Doordarshan has upgraded Earth Stations with MPEG-2/4 compliant SD/HD compression chain and spectrum efficient DVB-S/S2 compliant RF chain equipment. These earth stations are capable of uplinking HD/SD TV channels.

Doordarshan is using a total of 18.36 Transponders (12.03 C Band & 6.33 Ku Band) of 36 MHz each on GSAT System.

In addition, Doordarshan launched its free-to-air DTH service "DD Free Dish (Earlier DD Direct+)" with the primary objective of providing TV coverage to the uncovered areas. Initially, this service was started with a bouquet of 33 TV channels, and now, the capacity of DD Free Dish DTH platform augmented to 104 TV channels and 40 Radio Channels. Presently, DD Free Dish broadcasts 116 TV Channels (including one HD Channel) and 48 Radio Channels.

Satellite News Gathering and Events Broadcasting

Doordarshan has inducted 9 C-band DSNG vans equipped with MPEG-4 compliant SD/HD compression chains 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 & DSNG – 10 Channels) for National, Regional & 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 505 Down Link Radio Network Terminals (RNTs). AIR is also Broadcasting 48 Radio Channels on the DTH Platform of Doordarshan' DD Free Dish'.

Telecommunications

Indian communication 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 ATMs with banks.

2.2 Space Applications

About 1630 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 2.75 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 and strategic agencies.

Telemedicine

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

ISRO's Telemedicine programme connects various remote & rural medical colleges & hospitals to major specialty hospitals in cities and towns using satellite communication.

DECU/ISRO is providing Telemedicine (TM) services for various users across India, including strategic partners such as the Ministry of Defence (MOD) and the Ministry of Home Affairs (MHA). Several nodes for Defence & Paramilitary forces have been established in remote, inaccessible, and high-altitude areas such as Jammu & Kashmir, Leh, Ladakh, etc.. At present, around 180 Telemedicine nodes are operational. Out of these, around 95 Telemedicine nodes are located in high-altitude regions. DECU/ISRO signed four MoUs with Integrated Defence Staff (IDS-Medical), Indo-Tibetan Border Police Force (ITBPF), Border Roads Organisation (BRO), and Employee State Insurance Corporation (ESIC), respectively, in the financial year 2022-23.



In the year 2022, a new node was installed at Baltal, and a node was reinstalled at Panchtarani en route to Holy Cave Shri Amarnathji during Amarnath Yatra. Three nodes were established for ITBPF, and three more nodes are planned to be established for BRO. More than 60 nodes were revived after the repair/replacement of faulty items. Annual Maintenance Contract was continued for the nodes and the Telemedicine Hub. A Technology Development Programme (TDP) on next-generation Telemedicine System is undertaken by DECU.

Continuing Medical Education (CME) programmes are conducted from DECU's Studio as well as from remote user-ends in which medical experts/doctors share their knowledge & experiences and interact with connected remote hospitals. Till December 2022, Eight CMEs have been conducted.

Tele-education

Tele-Education (TE) networks supported the education system in the country through SATCOM-based Ground systems. It supplemented curriculum-based education for primary & secondary schools and undergraduate as well as postgraduate students. It also provided teachers training as and when required. The Tele-Education networks covered almost all the states, thereby taking education to the remote areas of the country. The TE networks were of two types, Non-interactive (ROTs) & Interactive (SITs).

Technical support was provided to various Tele-Education user agencies, such as Jammu & Kashmir, Uttarakhand, Karnataka, etc. on a requirement basis. Remote support was provided to the users for the indigenously developed 'Daksh' Learning Management System (LMS) from the DECU Monitoring facility. Lectures were transmitted on Haryana, Punjab & Kerala Tele-Education networks. Monitoring of Receive Only Terminal (ROT) channels, such as VICTERS, UTKARSH, etc., was carried out from DECU Tele-Education Monitoring Lab.

Ministry of Information & Broadcasting (MoIB) recently released an advisory that the Educational networks under state Governments shall be brought under suitable agreements between Prasar Bharati and the concerned State Government Agency. Accordingly, the user agencies were informed.

Social Research & Evaluation

Social science research is an integral part of various projects and activities of the Development and Educational Communication Unit (DECU), which is responsible for conducting studies in all the application areas involving the society-technology interface. Social research is carried out in many areas of societal applications such as

2.2 Space Applications

Telemedicine, Tele-Education, Earth Observation, Navigation, etc. Research helps in pre-project planning to assess the needs, during the project for mid-course correction, and at the end of the project to evaluate the success of the project.

DECU carries out several research studies independently as well as in collaboration with various other ISRO centres. This year various social research studies are completed/ongoing such as "Usefulness of SAC's Agro-met Product based Advisories on Agricultural Practices: A Study on Farmers in Parbhani District, Maharashtra", "Impact of SAC's Sponsored Research Projects at Academic Institutions in Western Region of India", "A Feedback Report on Educational Video Production Training", "Effectiveness of Bhuvan Geoportal among the Users", "Effectiveness of Geotagging and Monitoring of NEC/MoDNER (North Eastern Council/Ministry of Development of North Eastern Region) funded Projects/schemes in North Eastern Region using Geospatial Technology and Tools", etc.

Various internet studies such as the Impact of the MOSDAC Web Portal on Research Activities of Users, the Impact of the Indian Institute of Remote Sensing Online Learning Outreach Programmes, Exploring the Usefulness of North Eastern District Resources Plan (NEDRP) Geoportal in North Eastern Region of India, Socio & Economic Needs Assessment Study of Scheduled Tribes of Araku Valley in Andhra Pradesh, etc. was compiled.

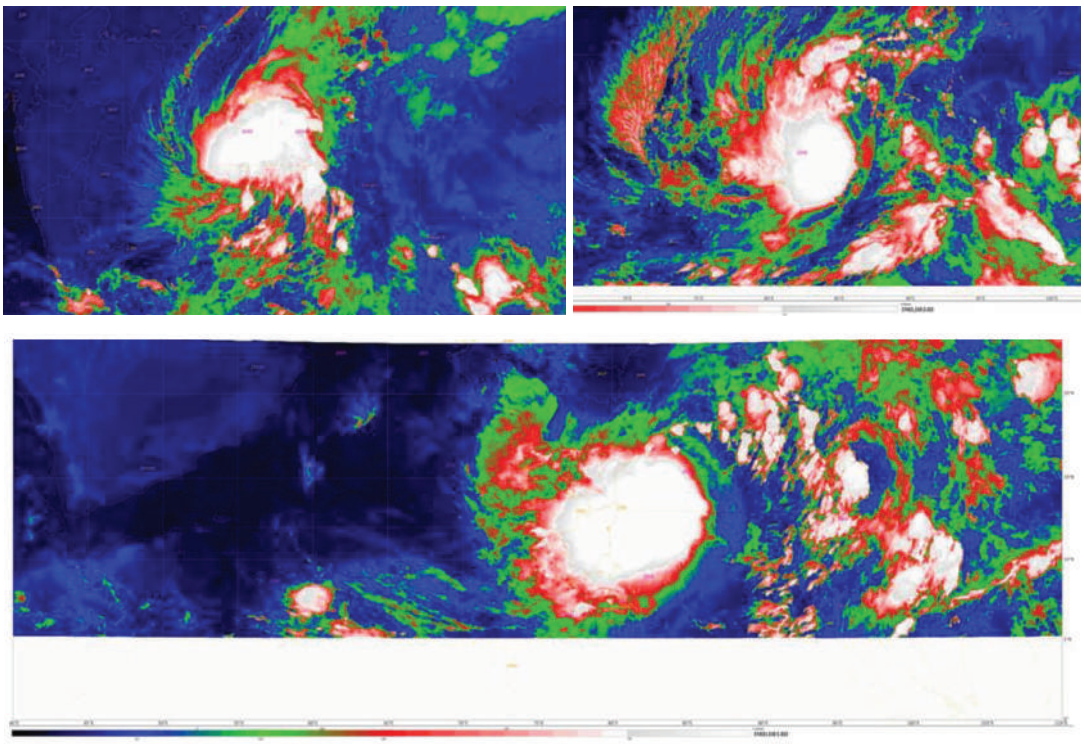
Satellite Meteorology

Satellites provide essential inputs for meteorological applications. INSAT-3D and INSAT-3DR (Imager, Sounder, DRT) satellites carrying meteorological payloads support 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 process the data of both INSAT-3D and INSAT-3DR. The performance of the system during the current year has been maintained at 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. 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.

Rapid scans were conducted during major cyclonic events like Asani, Sitrang, Mandous, etc, as per the schedule given next.

Cyclone and Intensity	Duration
SCS Asani	May 8-12, 2022
CS Sitrang	October 22-25, 2022
SCS Mandous	December 6-10, 2022



INSAT-3DR Imager rapid scan during cyclonic storms

Satellite technology is of great use in meteorology and plays a very significant role in the improvement of weather forecasting and dissemination. 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 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, the Airports Authority of India, Directorate General of Shipping and Defence Services, and the system has been operational for the past 30 years.

2.2 Space Applications

INSAT-3D (82Deg East), INSAT-3DR (74Deg East), and GSAT-17 (93.5 Deg East) carry Search and Rescue payloads operating in the 406 MHz band. 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 a 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 the Indian Coast Guard (Mumbai, Chennai, Port Blair) and the Rescue Coordination Centres (RCCs) of AAI (Chennai, 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.

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 under progress.

From January to December 2022, INMCC provided search and rescue support to 12 distress incidents in the Indian service area and contributed to saving 56 human lives. During this period, about 2493 new radio beacons were added to Indian database. To date, there are 1073 registered users, and total number of registered beacons is 19791.

Indian Coast Guard conducted the 24th beacon exercise involving various stakeholders and international participants during August 10-12, 2022, wherein INMCC detected and relayed a mock-up distress alert. Seminars and Workshops on SAR-related activities and operations were conducted for AAI, ICG and Defence, and other users.

MEOSAR project

ISTRAC is in the process of operationalizing the MEOSAR ground segment (MEOLUT). The ground segment consists of six 2.4m antennas (1 standby) associated with Servo, RF front-end, Digital receiver, Orbit determination, Monitor and Control, Schedule generation, Location Estimator, and related communication link.

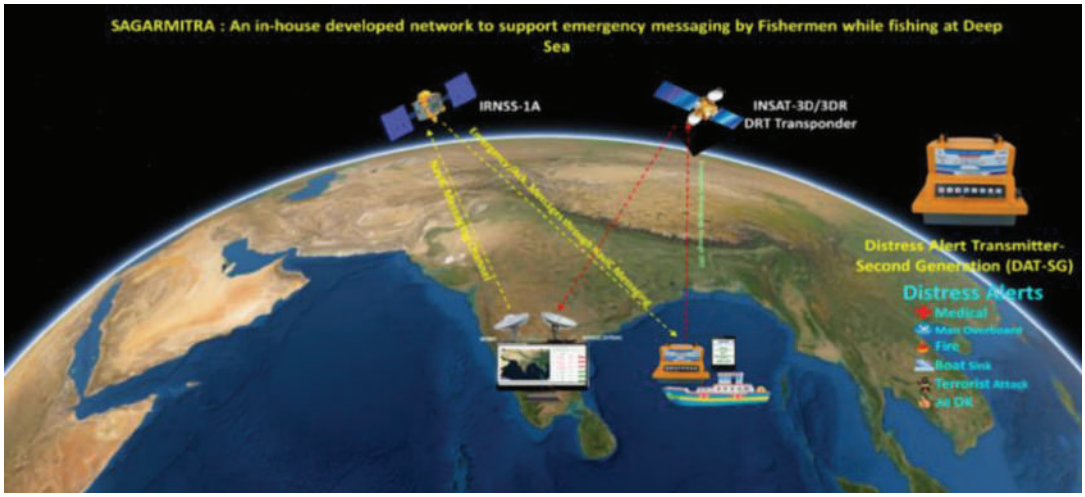
Subsystem T&E are in progress. Operationalization, final certification by Cospas-Sarsat, and dedication of the facility to the nation are planned in the near future.

Data Relay Transponders (DRT)

Data Relay Transponders (UHF x C) are flown on INSAT-3D, INSAT-3DR & GSAT-17 satellites. A data Relay Transponder (DRT) is used for collecting observational data such as weather data, ocean monitoring data, snow avalanches, disaster alert signals etc. Field-level terminals are one-way transmitters that uplink the observational data to satellites in the UHF band (402 MHz Band) at intervals. Such data is received by the downlink station at the user premises. More than 40,000 transponders have been deployed by different Government and institutional users for sensor data collection applications like AWS, Tsunami Early Warning etc.

Distress Alert Terminal

ISRO 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 DAT user registration database service for Indian fisherman communities. System T &E and commissioning is in progress.



DAT-2G Network

2.2 Space Applications

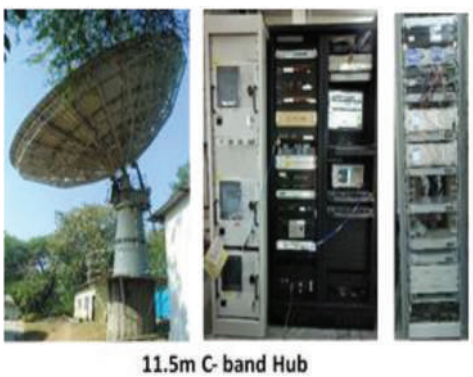
South Asia Satellite

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

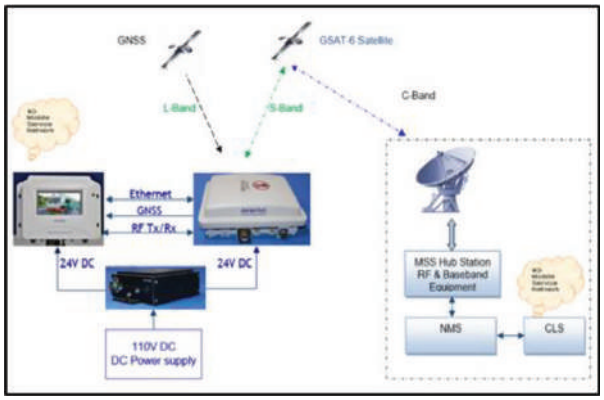
A SatCom network has been established using one transponder in Bhutan for utilisation of SAS and has been operational since January 2019. The local team has been trained to handle operations and maintenance of the network. The network is being used to uplink two TV channels and 4 Radio channels of Bhutan, Internet connectivity, connecting the Disaster Management Centers, and critical telecom links. Augmentation of ground systems to utilise an additional 20 MHz BW is in progress. Bangladesh has established a dedicated network with a hub in Dhaka to connect more than 100 schools using one transponder on SAS. An additional transponder is provided to them for the expansion of their Satcom network. In the Maldives, 4-5 terminals are reactivated through an Indian vendor, with support from the common Hub at DES, New Delhi. An enquiry for DTH services was received from Sri Lanka, and the technical details are provided. A project proposal for the establishment of a dedicated Satcom network with a hub and 300 terminals in Nepal is under consideration.

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 & Delhi with necessary baseband subsystems have been established to provide uninterrupted services & demonstration.



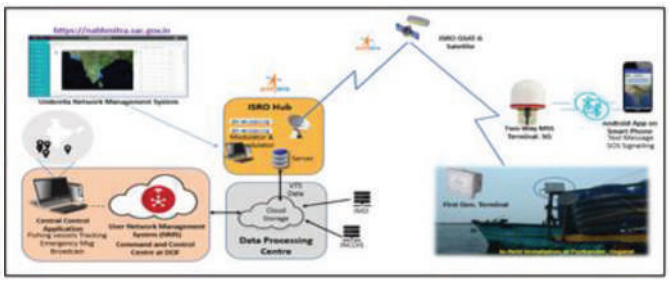
11.5m C- band Hub



RTIS Network

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 enables the enhancement of safety and operations of the Train services, particularly in strategic segments. This solution helps 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. Two years back, 2700 trains were covered with RTIS with the capability to track the position of locomotives in real-time. Further, 6000 trains are getting added with RTIS capability.

ISRO has developed SATCOM terminals for tracking sub-20m fishing vessels which go into the deep sea for several days. The system provides for both the safety of the fishermen as well as monitoring their movements for security reasons. Proof of Concept was demonstrated by installing 500 Terminals in Tamilnadu, Puducherry, and Gujarat. Further, Tamilnadu has undertaken the rollout of this solution for 5,000 fishing vessels. The installation is in progress.



Fishing Vessel Tracking Network

High Throughput Satellites

Broadband requirements are continued to increase, driven by the growth of the business, entertainment, penetration of wireless communications, and remote area connectivity. High Throughput Satellites (HTS) systems play a significant role in enhancing the bandwidth by adopting multiple spot beams with frequency reuse techniques. ISRO has launched GSAT-19, GSAT-11, and GSAT 29 HTS satellites together, providing 25 Gbps capacity. The capacity is used for the BharatNet project to provide broadband connectivity to Gram Panchayats (GPs) and also for other VSAT-based applications. For using these satellites, more than 6000 user terminals are deployed across the country.

2.3 Navigation Systems

Navigation with Indian Constellation (NavIC) is India's independent regional navigation satellite system catering to a coverage area of India and 1500 km beyond the Indian landmass. ISRO has established the space and ground infrastructure. ISRO is making continuous efforts to enable civilian sectors like land transportation, aviation, maritime, mapping, surveying, geodesy, timing, telecommunications, etc., to utilise the services offered by NavIC. GPS Aided Geo Augmented Navigation (GAGAN) is a space-based augmentation system for civil aviation purposes in the Indian region. ISRO has established the space segment, while the ground segment is established by the Airports Authority of India (AAI).

Major developments in navigation systems during 2022 have been:

1. Aadhaar enrolment devices

The Unique Identification Authority of India (UIDAI) has approached ISRO for technical guidance to integrate NavIC in the Aadhaar enrolment devices for capturing the location of the enrolment center on a periodic basis. ISRO provided NavIC-enabled receivers for proof-of-concept demonstration and gave technical assistance for seamless integration into the current client architecture. Based on a subsequent request from UIDAI, ISRO has provided 10 NavIC-enabled GNSS receivers for field testing. UIDAI successfully conducted field trials at various remote locations in the country, and the results were satisfactory. UIDAI is in the process of procuring receivers from the Indian industry for deployment throughout the country.

2. Time dissemination

ISRO and National Physical Laboratory (NPL) are working with the Dept. of Consumer Affairs to set up a country-wide time dissemination system. Under this project, one primary timescale will be established at Bengaluru, and five secondary timescales will be established at Ahmedabad, Bengaluru, Bhubaneswar, Faridabad, and Guwahati. These timescales will be integrated and operated with ISRO's in-house timescale software. These timescales will provide accurate IST dissemination across India and will contribute to enhancing cyber security resilience. The system architecture has been finalised, and equipment specifications have been cleared for procurement. The procurement process is ongoing.

3. CORS network

Continuously Operating Reference Stations (CORS) collect data for measuring and monitoring the movement of continental plates so that reference frame and datum

can be defined, improved, and maintained for geoscience and spatial datasets. Survey of India (SOI) is in the process of setting up CORS networks throughout the country. ISRO has developed NavIC-based high-accuracy receivers for the CORS application and has demonstrated the results to SOI. ISRO is in discussion with SOI for the subsequent inclusion of NavIC-based receivers in the national CORS network.

4. Consumer devices

Major mobile chipset manufacturers have released mobile processors which are NavIC enabled. There are about 35 mobile handsets in India with NavIC capability. Other consumer-grade devices like wearables, trackers, IoTs, etc., require small form factor low-power GNSS chips. These are generally catered to by single-frequency modules. In order to proliferate NavIC in this sector, the 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.

5. Messaging system

Indian National Centre for Ocean Information System (INCOIS) effectively uses the NavIC messaging system 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.

National Disaster Management Agency (NDMA) has evolved a Common Alert Protocol (CAP) for major natural disasters like landslides, earthquakes, floods, heavy rains, avalanches, etc. NavIC messaging system has been identified for phase-1 implementation as a disseminating system. ISRO has provided technical support to the implementing agency C-DOT in this regard, and development is as per schedule. ISRO and C-DOT teams have finalised the interface control document. The C-DOT team is developing mobile-based applications for the data received through NavIC messages.

ISRO is also studying the feasibility of a standard alert protocol in-line with the system devised by Galileo and QZSS.

6. Industry standards

a. Maritime

International Electrotechnical Commission (IEC) develops standards for GNSS-based

shipborne receiver equipment. ISRO has contributed for the inclusion of NavIC in the relevant IEC standard, with the support of the Bureau of Indian Standards (BIS). IEC working group member states have reviewed and approved the new IEC 61108-6 standard for NavIC.

Additionally, a common SBAS standard is being drafted by the IEC. ISRO has collaborated with European EGNOS to develop the specification document. Draft IEC 61108-7 standard for SBAS, which includes GAGAN, is currently being reviewed by the member states. ISRO and AAI actively participated in the discussions and provided inputs.

b. Differential GNSS

NavIC S-band has been included in Radio Technical Commission for Maritime Services (RTCM) 10403.3 amendment-3 standard released in August 2022. With this, both L5 and S bands are part of the RTCM standard. This enables NavIC dual band in the differential GNSS being extensively used by the Directorate General of Shipping.

c. Unmanned aerial vehicles

BIS has released the national standard IS 17799:2022 for agricultural drones. NavIC is included in the specification for a drone navigation system. BIS is also in the process of drafting a national standard for generic drones. ISRO has actively participated in the discussions and provided relevant technical inputs.

2.4 Space Science Exploration and Research

Space Science exploration and research have been important driving forces of the Indian space programme. The space science research activities are pursued at premier research laboratories of ISRO / DOS, and feasibility studies are undertaken in several ISRO Centres. A number of space science research projects in the field of atmospheric science, astronomy and planetary science and science payload development activities are supported and implemented at various Universities and Research Institutes by ISRO through the Announcement of Opportunities. The major activities carried out under space science exploration and research during 2022-23 are summarised below.

Space Science Missions

Mars Orbiter Mission (2014-2022)

The Mars Orbiter Mission, despite being designed for a life-span of six months as a technology demonstrator, has lived for about eight years in the Martian orbit. The mission has gifted a gamut of significant scientific results on Mars as well as on the Solar corona. In April 2022, the mission was declared as complete.. The mission will be ever-regarded as a remarkable technological and scientific feat in the history of planetary exploration.

AstroSat (Ongoing, from 2015)

AstroSat is India's first observatory class mission, dedicated to astronomy, which is capable of simultaneous measurements from Optical to high-energy X-rays. AstroSat is in its 8th year of operation and expected to continue to provide excellent science data for a few more years. The data from AstroSat have resulted in multiple discoveries and several scientifically significant results. The data are used by close to 2000 users from the national and international astronomy community. AstroSat data have resulted in a total of 275 research articles in its first seven years of operation and 20 theses made use of AstroSat data in the same period.

Some of the major science results that came out of AstroSat data during the period are,

1. Discvovery of extended emission in distant dwarf galaxies using UVIT.
2. Spectral transition in the changing-look active galaxy NGC 1566 during the declining phase of the 2018 outburst.
3. Multi-wavelength observations of spectral states of OJ 287 blazer

Chandrayaan-2 Mission (Ongoing, from 2019)

Chandrayaan-2 orbiter is currently orbiting the Moon at 100 km polar orbit and completed three successful years around the Moon on August 20, 2022. All eight

2.4 Space Science Exploration and Research

payloads are operational and continue studying the Moon's topography, mineralogy, composition, exosphere and sub-surface features. The payload operation and spacecraft configuration changes are carried out as per the season due to Sun-Orbiter plane geometry. Accordingly, optical payloads such as Terrain Mapping Camera-2 (TMC-2) and Imaging Infrared Spectrometer (IIRS) are operated in the noon-midnight season and Dual Frequency SAR (DFSAR) payload is operated during the dawn-dusk season. CLASS, XSM, CHACE-2 and DFRS are being operated in all seasons. Special imaging operations with Orbiter High-Resolution Camera (OHRC) are carried out to image candidate landing sites for future lunar missions. Periodic orbit manoeuvres were carried out to maintain the orbiter in a 100 km circular polar orbit.

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 a greater advantage of observing the solar activities and their effect on space weather. The payloads of Aditya-L1 are in advanced stages of development to meet the launch schedule. Three of the scientific payloads of the mission have already been delivered for Assembly, Integration and Testing.

In order to increase the national user base for the Aditya-L1 mission, two national workshops were conducted with hands-on training to analyse the various types of solar data. These workshop were conducted under the Aditya-L1 Support Cell, a

Participants during the second workshop of Aditya-L1 conducted under Aditya-L1 Support Cell.

joint initiative by ISRO and Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital. The first workshop, which was a 10 days long duration workshop was conducted in ARIES for the duration June 27, 2022-July 6, 2022 for M.Sc and senior engineering students. The second workshop was conducted in Manipal Academy of Higher Education (MAHE), Manipal for PhD students in the duration November 28-30, 2022.

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 8-30 keV photons while XSPECT will give spectroscopic information of soft X-rays in the energy range of 0.8-15 keV. Both payloads are at different stages of development.

International Co-operation in Space Science Research

ISRO is engaged in various science cooperation activities in space sciences with other space agencies. Various working group are formed with other space agencies to take forward the cooperatives areas of common interest in space science. In this regard, discussions have taken place under the umbrella of ISRO-NASA Planetary Science Working Group, ISRO-NASA Heliophysics Working Group, ISRO-ASI in Heliophysics and lunar science, ISRO-NOAA in Heliophysics cooperation, meeting with representatives from NASA, ESA, SANSA, CNES, CONAE, CSA and Russian Academy of Sciences (RAS) on the exploration of various cooperation areas in space sciences. A feasibility study for a future lunar polar exploration mission is in progress between ISRO and JAXA.

Space Science Capacity Building and Outreach Activities

National Space Science Symposium 2022 (NSSS 2022)

National Space Science Symposium 2022 was organised virtually in collaboration with IISER Kolkata during January 31, 2022 and February 4, 2022. The conference included Interdisciplinary sessions and five parallel sessions. The conference was presented with 228 contributed talks and 29 invited talks in addition to public lectures and 236 poster presentations. The proceedings were live-streamed and watched by more than 2100

2.4 Space Science Exploration and Research

attendees. Multiple outreach activities were organised nationwide for school/college students like model making, painting, and short videos.

NSSS-2022 online Inauguration Ceremony

The outreach part of the National Space Science Symposium-2022 was organised during December 5-11, 2022, in the city of Kolkata. It comprised rural outreach programme, a space science exhibition, public lectures and several other events. The exhibition was organized by the Center of Excellence in Space Sciences India (CESSI) and was supported by ISRO, IISER Kolkata, S.N. Bose National Centre for Basic Sciences and the National Council of Science Museums, Ministry of Culture. There were a total of 20 different organizations participating in the exhibition with more than 90 scientists and PhD students involved in various outreach activities, public lectures and panel discussions.

Glimpses of the rural scientific outreach programme organised at St. Xavier's College, Raghabpur Campus, West Bengal, on December 05, 2022

The National Space Science Exhibition organised in Science City, Kolkata during December 6-11, 2022

National Meet on Venus science

ISRO had organized a one-day National meeting on Venus science, in virtual mode, with the theme 'Outstanding Scientific Problems on Venus: Need for Space-based Studies', to brainstorm on the scientific contexts and possibilities of Venusian science. The event witnessed active participation from several academic and research

institutes, that included eleven scientific lectures from IIT-Delhi; IIT-Bombay; IIT-Roorkee; IIA, Bengaluru; IISER, Kolkata; IIG, Mumbai; CUSAT, Kochi; SPPU, Pune; Amity University, Noida, and more; and four lectures from ISRO/DOS.

Online Inauguration of Venus Science National Meet

This national meet comprised three sessions. The first session was dedicated to the scientific context of the Venus exploration, and the mission challenges. The second session focused on the science expected from the space-based experiments from the proposed Venus mission, on the facets of the Sun-Venus connection, Venusian atmosphere and ionosphere, and Venusian surface and subsurface. The third session, titled 'Opportunities for the User Community,' was dedicated to opening up the opportunities to establish an association between ISRO/ scientists and the scientists/academicians from the academic institutes. This session aimed at laying the plan for synergizing the experience, wisdom and expertise of the scientists of the country, to build an effective Venus science community, and, to take the flag of the future Venus missions forward.

National Meet on Aeronomy Research

The national meet on Aeronomy research was conducted at ISRO HQ in online mode on May 10, 2022. Fourteen speakers spoke on various aspects of Aeronomy research. There was a panel discussion in which nominees from various ministries (Ministries of Civil Aviation, Communication, Power, Earth Sciences, Science and Technology, Electronica and Information Technology, and Information and Broadcasting) and the scientific research community expressed their views on the utility of the proposed Disturbed and quiet-time Ionosphere-thermosphere System at High Altitudes (DISHA) mission in research and applications on effects of space weather, and disturbances arising from internal atmospheric processes (e.g., gravity waves, planetary waves, etc.). Researchers from 10 universities, 8 national institutes, and a few foreign universities showed interest in utilisation of the data from proposed DISHA mission. A draft version of the handbook on the Indian mission for Aeronomy, DISHA H & L has been prepared wherein directory of researchers and their plan of utilisation of the data from the Aeronomy mission is also included.

2.4 Space Science Exploration and Research

Screenshot of National Meet on Aeronomy Research

National Meet on Mars Orbiter Mission (MOM)

Inauguration ceremony of National Meet on Mars Orbiter Mission

On September, 27, 2022, ISRO had organized a one-day National meet to commemorate the Mars Orbiter Mission, on the event of completion of its eight years in the Martian orbit. The event witnessed active participation from several academic and research institutes, that included IISc, Bengaluru, Bangalore University, NIT-Rourkela, Tripura University, and Gorakhpur University, to name a few, as well as the centres and units of ISRO/DOS. The event was live-streamed to the ISRO website, and the ISRO social media platforms.

During the meeting, it was also presented that there has been a high demand for the Mars Orbiter Mission data globally. So far, more than 7200 users have registered to download the MOM data from the portal of the Indian Space Science Data Centre (ISSDC), 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.

The deliberations during the national meet covered topics on the challenges faced by the Mars Orbiter Mission, lessons learnt from them, how to access the mission data from the portal of the Indian Space Science Data Centre (ISSDC), as well as a series of

Participants of the National Meet on Mars Orbiter Mission

detailed presentations on the science outcomes by the principal investigator teams as well as the academia partners. A session was dedicated to a panel discussion on 'Future Exploration of the Inner Solar System: Scope and the Focus Areas' with the participation of Indian academia/institutes and ISRO/DOS.

National Conference to celebrate seven years of AstroSat

A two-day national conference was organised in September to celebrate seven years of AstroSat in orbit. The conference was well attended by more than 150 astronomers from India and abroad. The proceedings of the conference were also live-streamed.

The inaugural ceremony of AstroSat national conference

International Moon day

International Moon day was celebrated on July 20, 2022 by various centres of ISRO. Space Quiz on Moon, painting/ poster competition, and public talks were conducted as part of the celebration. During this occasion, hands-on kits and outreach booklets were also distributed among school children across the country as part of outreach activities.

2.5 Space Transportation Systems

Space Transportation System

Space technology is vital as it has a positive impact on everyday life and society. Assured access to space is a critical goal for the nation's technological advancement, scientific discovery, security, and economic growth. The Indian Space Programme has made a successful transition in terms of technology acquisition and launch vehicle development. Self-reliance in space transportation systems has been an important component of the guiding vision for the Indian Space Programme in the development of space technology and its applications for societal development. The country has achieved self-reliance in space transportation capability through the operationalization of Polar Satellite Launch Vehicle (PSLV), Geosynchronous Satellite Launch Vehicle (GSLV), and Launch Vehicle Mark 3 (LVM3) vehicles for launching satellites for earth observation, communication, navigation, and space exploration. PSLV mirrors the steady rise of India's space programme by presenting itself as a cost-effective launch vehicle both for the nation's progress along with sustaining its leading position as a preferred vehicle for providing commercial launch services to other nations. The increased demand for small satellite LEO constellations 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 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 LVM3 configuration is being realised to transport humans safely to LEO. The assured capability to access space and strengthening 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.

Major Events

- **Polar Satellite Launch Vehicle (PSLV):** Polar Satellite Launch Vehicle (PSLV) completed its 56th launch during the reporting period 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-C52 / EOS-04: Polar Satellite Launch Vehicle PSLV-C52 injected Earth Observation Satellite EOS-04 (Earth Observation Satellite - 04) into a sun-synchronous polar orbit of 529 km altitude on February 14, 2022, from Satish Dhawan Space Centre, SHAR, Sriharikota. This was the 80th launch vehicle mission from SDSC SHAR, Sriharikota. The vehicle also carried two small co-passenger satellites and were successfully separated from the PSLV in a predetermined sequence.
* PSLV-C53 / DS-EO: PSLV-C53 successfully launched and injected the DS-EO satellite along with two other co-passenger satellites (NeuSAR & Scoob-1) for Singapore into an altitude of 570 km on June 30, 2022, from the Second launch pad at Satish Dhawan Space Centre, SHAR, Sriharikota. PSLV-C53 is the 2nd dedicated commercial mission of NewSpace India Limited (NSIL). This was the 55th mission of PSLV and the 15th mission using PSLV-Core Alone variant. The mission also demonstrated for the first time the utilisation of the spent upper stage of the launch vehicle, i.e., PS4 stage, as a stabilized orbital platform named as PSLV Orbital Platform Experiment Module (POEM) for carrying out in-orbit scientific experiments after the separation of satellites. POEM carried six payloads, including two from Indian Space Start-ups M/s Digantara and M/s Dhruva Space, enabled through IN-SPACe and NSIL.
* PSLV-C54 / EOS-06: PSLV-C54 successfully launched the third-generation satellite in the Oceansat series i.e., EOS-06 (Earth Observation Satellite - 06) along with Eight Nano-satellites into two different Sun-

PSLV-C52/EOS-04 Mission

PSLV-C53/DS-EO Mission

PSLV-C54/EOS-06 Mission

2.5 Space Transportation Systems

Synchronous Polar Orbits on November 26, 2022, from Satish Dhawan Space Centre SHAR. The Primary satellite (EOS-06) was separated in Orbit-1, i.e., at an altitude of 738 km. Subsequently, orbit was changed using two Orbit Change Thrusters (OCTs) introduced in the Propulsion Bay Ring of the PSLV-C54 vehicle, and all the seven commercial satellites from NSIL & INS-2B (India-Bhutan Sat) were deployed successfully in Orbit-2, i.e., at an altitude of 511 km. This was the 56th flight of PSLV and the 24th flight of the PSLV-XL version.

* Missions of PSLV that are planned to be launched in 2023 include Aditya-L1, Dedicated commercial assignments of NSIL, and a Technology demonstration satellite mission (TDS-01).

- **Geosynchronous Satellite Launch Vehicle (GSLV):** GSLV is a three-stage vehicle with solid, liquid, and cryogenic upper stage, designed to place a 2000 kg class of communication spacecraft in the Geosynchronous Transfer Orbit (GTO).

  * With respect to the anomaly observed in the GSLV F10 mission, which took place on August 12, 2021, a national FAC (Failure Analysis committee) was constituted in order to identify the root cause of the failure and suggest possible modifications. Detailed analysis by FAC has been completed, and the root cause of the failure has been identified. The modifications/ improvements suggested by the committee are being implemented, and the next launch of GSLV (GSLV F-12/NVS-01) is scheduled during the first quarter of 2023.

- **Geo Synchronous Satellite Launch Vehicle MKIII (LVM3):** LVM3 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).

LVM3-M2/OneWeb India-1 Mission

  * LVM3-M2: LVM3-M2 mission successfully launched the first dedicated commercial mission, i.e., OneWeb India-1 mission for a foreign customer M/s Network Access Associates Ltd., a UK-based company, through NSIL launching 36 satellites weighing together approximately 5800kg to LEO into an altitude of 601km on October 23, 2022, from the Second launch pad at Satish Dhawan Space Centre, SHAR, Sriharikota. There were many first during the mission, which includes 1st commercial mission of

LVM3, 1st multi-satellite mission of LVM3 with 36 OneWeb Satellites, 1st launch of LVM3 to LEO, 1st Indian launch vehicle to carry 6 tons payload to LEO. With this launch, LVM3 made its entry into the "Global commercial space launch service market". This mission was the 5th mission of LVM3 and the 83rd launch from Satish Dhawan Space Centre, SHAR, Sriharikota.

* Future missions of LVM3 planned to be launched in 2023 are 2nd commercial mission of NSIL, i.e., the OneWeb India-2 mission, and country's third lunar mission (Chandrayaan-3).

Development efforts towards the human rating of LVM3 (Gaganyaan Programme)

- Launch vehicle structures have been redesigned to meet the required human rating factor. Solid motor segments required for static test were realised, and successful static testing of the HS200 motor was completed. UH25 and N_2O_4, propellant tanks required for the first unmanned mission (G1) have been realised. Towards qualification of the Vikas engine required for Human rated L110 stage, one medium duration test (60 s), three long-duration qualification tests (730 s), and four off-nominal tests (100 s) have been successfully completed. Further, one long-duration test (240 s) is planned to be carried out in February 2023. As part of the structural qualification test, the N_2O_4 & UH25 propellant tanks have been realised, and activities towards carrying out the test are being done. Towards qualification of the CE20 engine required for the C25 stage, in total 8 hot tests (One short duration test, three long duration tests and 4 off-nominal tests) for a cumulative duration of 2650 s have been completed on the E9 engine hardware at MET facility as part of Gaganyaan qualification. With the completion of the above-mentioned tests, the CE20 E9 engine demonstrated the human rating requirements of (a) a Hot firing test up to 4 times the service life, (b) Endurance duration firing in a single test, and (c) Demonstration of off-nominal testing with ±5% chamber pressure & mixture ratio. Subsequently, 3 hot tests (one short-duration test & two long-duration tests) for a cumulative duration of 1300 s during Q2 2023 to complete the cryogenic engine qualification for the Gaganyaan Programme.
- **Small Satellite Launch Vehicle (SSLV):** SSLV is an all-solid three-stage vehicle capable of launching mini, micro, or nano class satellites (10 to 500kg class) into 500km planar orbit. The first developmental flight of Small Satellite Launch Vehicle, SSLV-D1, lifted off with EOS-02, an earth observation satellite & a co-passenger student satellite, Azadisat, on August 07, 2022, from the First launch pad at Satish

2.5 Space Transportation Systems

SSLV-D1/EOS-02 Mission

Dhawan Space Centre, SHAR, Sriharikota. The lift-off of SSLV-D1 was normal, and the flight data indicates the normal performance of all solid propulsion stages. However, the mission objectives could not be achieved due to an anomaly during the separation of the Second stage motor (SS2). The satellites were injected into a highly elliptical unstable orbit due to a shortfall in velocity, leading to their decay and deorbiting immediately. A Failure analysis committee was immediately constituted to identify the causes of the mission anomaly and to recommend corrective actions for future missions. The committee has completed its deliberations and provided recommendations. The modifications have been implemented, and the next developmental flight of SSLV (SSLV-D2) is scheduled in the first quarter of 2023.

- **Reusable Launch Vehicle (RLV):** The objective of the RLV programme is to demonstrate critical technologies required for developing a wing body reentry vehicle similar to that of an aircraft. Integrated Technology Demonstrator Vehicle along with landing gears and avionics systems realised. Helicopter drop tests were attempted from April to June 2022. However, the RLV-LEX mission could not be completed due to the unfavorable weather conditions at the landing site that is located in Chitradurga. Further landing experiments are planned to be completed during Q1 2023.
- **Test Vehicle Project (TVP):** The 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, carries CES as payload, and places it at the predefined "M-q' pill box. Out of the two vehicles to be realised, 1st test vehicle (TV-D1) has been realised and positioned at SDSC SHAR Sriharikota, for further activities, and the launch of 1st Test Vehicle (TV-D1) flight is expected during Q1 2023. Further activities towards the realisation of 2nd test vehicle (TV-D2) is in progress. All the necessary developmental test activities, such as wind tunnel tests, acoustic tests, structural tests, and dynamic characterisation tests, have been completed.
- **Semicryogenic Propulsion System Project:** The Semicryogenic Propulsion System project envisages the design and development of a 2000kN semi-cryogenic

and SC120 stage that will enable the development of a heavy-lift capability for future Indian Space Transportation Systems. The development of seven out of eight engine subsystems, have been completed. The intermediate configuration of the engine (Power Head Test Article) has been realised, wherein all the subsystems have been manufactured through Indian industries. The first major test for the immediate configuration i.e., PHTA is planned in the fourth quarter of 2022-23 from the Integrated Engine Test stand, which is expected to be commissioned by the end of February 2023. One ISROSENE propellant tank and two sets of LOX propellant tank for the semi-cryogenic stage have been realised through industry, which has successfully undergone proof pressure tests. Structural qualification tests on both the ISROSENE & LOX tank are to be carried out, for which various preparatory activities are in progress. Structures required for the SC120 stage are in different stages of realisation.

LOX Tank

Isrosene Tank

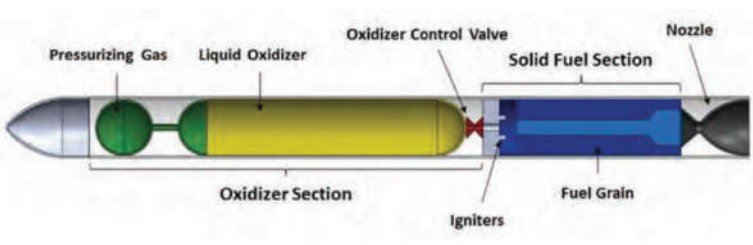
- **Uprated Cryogenic Stage Project (C32):** Uprated C32 stage project envisages the design, development and realisation of an uprated thrust cryogenic engine and higher loading cryogenic Stage, which will enhance the payload capability of the LVM3. Two sets of higher loading LOX & LH2 propellant tanks, and one each closed Inter Tank Structure (ITSc) & composite thrust frame have been realised. The structural qualification test for the composite thrust frame at LN2 temperature was completed successfully. Activities towards the structural qualification test for the propellant tanks are being carried out and are expected to be completed by Q2 2023. Towards the qualification of the uprated CE-22 engine, the first short duration (70 s) upratement test on the E9 engine to a thrust level of 21.8 tons has been completed successfully. Cryogenic engine (CE-20) has successfully undergone 2nd hot test for a long duration of 650 s with uprated thrust level of 22t thrust on December 23, 2022. Further, a series of long-duration hot tests are planned for the qualification of an uprated CE22 engine by Q2 2023.
- **Air Breathing Propulsion Project (ABPP):**

  Development of Critical Technologies for Hypersonic Air-Breathing Vehicle with Airframe integrated system: Air Breathing flight technology demonstration programs would lead to the design and development capability of advanced

air-breathing engines enabling low-cost access to the space transportation 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 glides down to 25 km altitude with a Mach number of 6. The objective is to demonstrate the accelerating flight of a hypersonic vehicle with a scramjet engine powered from Mach 6 to Mach 7 in 250 s at constant dynamic pressure. Several critical technologies have been identified, which are planned to be developed and demonstrated. Configuration designed for HAVA air intake cowl opening mechanism. Functional tests on the igniter required for HAVA were completed assessing the integrity of the hardware for repeated use. C-SiC preforms of size 200 mmX200 mm required for TPS panels realised through the industry. Integrated Strut igniter hot tests were carried out successfully. CFD simulations were carried out to study aero-propulsion data at higher angles of attack for HAVA vehicles. Overall external configuration for HAVA with the test vehicle finalised for realisation and testing of the wind tunnel models. A 1:8 scale model of HAVA vehicle realised for wind tunnel test. Functional hot test of scramjet facility air heater successfully carried out with the GH2/GO2 spark igniter developed in-house.

- **Advanced Technology Vehicles & Sounding Rockets (ATVP):** Advanced Technology Vehicle Program is meant for conducting sounding rocket development & launches 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 introducing into launch vehicles.

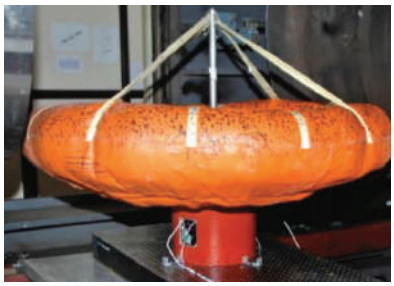
30 kN Hybrid Motor: Successful realisation and testing of a hybrid solid motor at ISRO Propulsion Complex (IPRC) carried out on September 20, 2022. The motor uses Hydroxyl-terminated polybutadiene (HTPB) as fuel and liquid oxygen (LOX) as the oxidizer, unlike conventional propulsion systems. The testing of a flight equivalent 30 kN hybrid motor demonstrated ignition and sustained combustion for a duration of 15 s, and the performance of the motor was satisfactory.



30 kN hybrid solid motor test

The hybrid motor tested is scalable & stackable, including the advantages of throttling & restart, which will pave the way forward for a new propulsion system for application in future launch vehicles.

- **Rohini Sounding Rocket flights:** A total of 8 RH-200 rockets were successfully launched this year from the TERLS range. So far, 200 consecutively successful launches of RH200 rockets have been conducted. The 200th consecutive successful flight of RH-200 was launched on November 23, 2022, from the TERLS Launch pad in VSSC and was witnessed by Shri Ram Nath Govind, Former honorable President of India.
- **RH300 MkII / Inflatable Aerodynamic Decelerator (IAD) Technology Demonstration:** Launch of Inflatable Aerodynamic Decelerator (IAD) Technology was successfully conducted on September 03, 2022 and all the objectives of the technology demonstration of Inflatable Aerodynamic Decelerator were met. The IAD technology will be used to decelerate a payload while it descends through a planet's atmosphere using the concept of aerodynamics. The IAD was folded and kept inside the payload bay of the rocket, and it later inflated at an altitude of 84 km and descended through the Earth's atmosphere exactly as planned. The demonstration opens a gateway for cost-effective spent stage recovery using the Inflatable Aerodynamics Decelerator technology.



Inflatable Aerodynamic Decelerator

RH300MkII/ IAD Technology Demonstration Flight

2.6 Gaganyaan

I. Introduction:

Gaganyaan is a national programme to demonstrate the capability to launch human beings to low earth orbit on an Indian launch vehicle and bring them back safely to earth. It comprises two uncrewed flights followed by a crewed flight involving detailed qualification of several engineering subsystems, crew selection & training, and development of human-centric products. The mission is broadly divided into three major phases, namely, ascent phase, orbital phase, and descent phase. In the ascent phase, the launch vehicle carries the Orbital Module to a low earth orbit. In the orbital phase, the Orbital Module revolves around the Earth for a period of up to three days. The orbital phase starts with the injection of the Orbital Module by the launch vehicle into an elliptical orbit. This is further raised to a circular orbit using the engines present in the Orbital Module. The orbital phase ends with the beginning of the de-boost maneuver carried out to initiate the return journey. The descent phase begins with the de-boost maneuver which sets the course of the module towards the designated touch-down location. A series of activities will be carried out during the descent phase, which will finally end with a low-velocity splash down at a designated location in sea waters. The Gaganyaan programme involves complex and multi-disciplinary activities with an emphasis on human-centric approach in designing, realizing, and testing various subsystems.

II. The Gaganyaan Programme::

The programme comprises of new technology areas which are necessary to execute the mission.

1. Development of Human Rated Launch Vehicle [HRLV]

1.1 HS200 Qualification

To meet the human rating requirements for the Gaganyaan programme, the S200 solid motor of the LVM3 booster stage is modified for improved Factor of Safety (FoS) in design and redundant defences in joints for added reliability. The first static test of

HS200 Static test

Igniter Qualification Test

the Human rated S200 (HS200) motor was successfully completed at SDSC-SHAR on May 13, 2022. Performance of the propulsion system with an Electro-Mechanical Actuator [EMA] system has been demonstrated. Post-test observations are satisfactory.

The S200 Igniter qualification tests were completed on July 18, 2022.

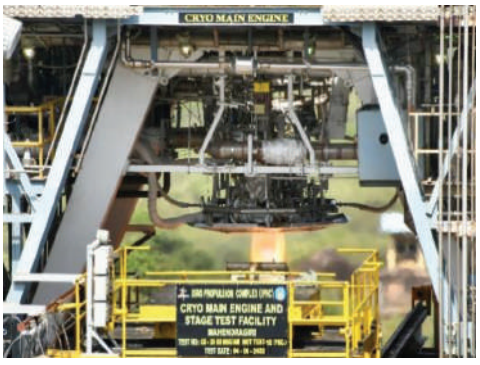
1.2 L110 - VIKAS Engine Qualification

L110 stage is the second stage of LVM3, having two Vikas engines. Human-rated L110 stage is configured with high-thrust Vikas engines operated at nominal thrust levels to ensure crew safety. For the stage controller of the L110 stage (Quad configuration), hot test package realised. Injector acceptance tests completed. The third off-nominal test was successfully completed on VIKAS Engine as part of a qualification test for 25 s continuous duration at IPRC on July 19, 2022.

VIKAS Engine third off-nominal test

1.3 C25 Engine Hot test (E9 engine)

The C25 stage is human-rated with additional features to meet the design factors recommended for manned vehicles and with certain modifications based on the previous flight performance. The stage is powered by a CE-20 engine having a nominal thrust of 186.36kN and operates on a gas generator (GG) cycle. The human rating of the C25 stage called for the redesign of the LH2 tank, FE dome and the introduction of flanged tank nozzles for improving reliability. The E9 engine long duration hot tests HT-09 & HT-10 with respective durations of 720 s and 760 s with nominal operating conditions were successfully completed at MET, IPRC, Mahendragiri on April 13, 2022 and June 4, 2022, respectively.



C25 Engine hot tests (HT-09 & HT-10)

1.4 Crew Escape System [CES]

1.4.1 Qualification & Realisation of Crew Escape Systems Motors

Crew Escape System (CES) comprises 5 different types of quick-acting solid motors viz., High Altitude Pitch Motor (HPM), Low Altitude Pitch Motor (LPM), CES Jettisoning Motor (CJM), High Altitude Escape Motors (HEM), and Low Altitude Escape Motor (LEM). Static qualification tests (Phase-1) have been completed for all solid motors of CES as follows:

2.6 Gaganyaan

HPM & LPM Static Test: Static test successfully completed for HPM & LPM motors at VSSC.

HEM Static Test: The 1st Static Test was successfully conducted on April 11, 2022. Two batch acceptance tests have also been carried out.

CJM Static Test: 1st Static test was successfully completed at SDSC SHAR on June 23, 2022.

LEM Static Test: Low altitude Escape Motor (LEM) Static test was completed on August 10, 2022.

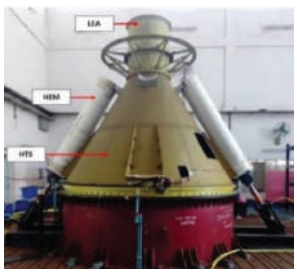
HEM Static Test

CJM Static Test

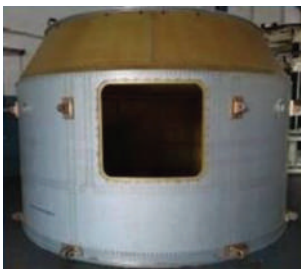
LEM Static Test

1.4.2 Readiness of CES Structures for Qualification:

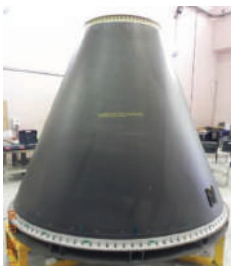
Three sets are realised, and structural tests are completed for Fore End (FE) structures. HEM Thrust Transfer Structure (HTS) hardware realisation and structural test completed. Crew Module Fairing (CMF) hardware realisation and main structure assembly completed. Crew Escape System Conical & Ogive Shroud (CECS & CEOS) realisation nearing completion.



HTS Structural Test



CMF before TPS application



CECS

CEOS

1.5 Test Vehicle Mission

Before the first crewed flight, four nos. of test vehicle flights, i.e., TV- D1, TV-D2, TV-A1 and TV-A2, are envisaged towards demonstrating and validating the characteristics and performance of the Crew Escape System and parachute-based deceleration systems. Mission design has been completed for the 1st Test Vehicle mission. The

nominal trajectory has been firmed-up. Coverage analysis is carried out for visibility of the Telemetry antennae of the Crew Module from the ground receivers. Mission design with Real-Time Decisions (RTD) based parachute events is worked out, in-order to avoid dispersions in the CM trajectory and the parachute deployment altitudes. Medium Earth Orbit Local User Terminal (MEOLUT) testing is carried out successfully between ISTRAC and SAC to receive, process, and display Ultra-High Frequency (UHF) beacon location in the recovery console.

1.6 Other developments for First uncrewed (G1) Mission

An analytical method for the prediction of instantaneous impact points for de-boost at any point in an orbit developed. Using this method, the impact point of CM can be predicted using the current position and velocity vectors of the OM in orbit. Software for automated computation of visibility statistics for Gaganyaan from ISTRAC and external ground stations and IDRSS is developed. The software also generates the timeline graph of major events in different orbits in relation to the visibility periods from different ground stations.

Separation dynamics studies were carried out for Apex Cover separation during the atmospheric descent of the crew module. Criticalities were observed in terms of the gap between other components in the apex region of the CM, as well as the stand-off distance of the Apex Cover required for the safe deployment of Drogue Parachutes. Descent mission studies have been carried out for de-boost at various points in an orbit. Various mission parameters, such as de-boost delta-V (velocity), propellant consumption, downrange, etc, have been studied. Mission analysis has been carried out for on-orbit audio communication gap during various orbits of G1 mission considering blockage of Field of View of various antennas on the crew module due to OM deployed solar panels & other elements to clear the locations of S-band antennas on Crew module.

Slosh studies for orbital phase and de-boost are completed to assess the requirement of anti-slosh baffles in propulsion tanks. The nominal and abort scenario-related snap events with respect to applicable flight regimes are worked out.

2. Development of Orbital Module [OM]

Orbital Module consists of Crew Module (CM) and Service Module (SM), designed to keep the crew safe during ascent, orbital phase, and re-entry. The design of various systems of Crew Module and Service Module was completed.

2.6 Gaganyaan

2.1 Crew Module [CM] for TV (Test Vehicle) & G1 Mission

2.1.1 System Engineering & CM Readiness

Layout & accommodation of subsystems has been carried out, and interfaces have been defined. Apex cover aero surface static analysis is completed for various pressure loads. Major components like the apex ring, apex base ring, and longerons are realised. Performance analysis is carried out for sea impact for different mounting angles with a secondary container for an active sea marker dye ejection system. Design of interfaces of post touch-down elements in crew module recovery is completed. Design/ analysis & technical review of metallic honeycomb sandwich CM decks has been completed. Preliminary accommodation of the ECLSS system and half-humanoid in G1 is completed.

Hyper-velocity Impact tests on MMOD protection shield

Crew Module sub-assembly for structural test

Heat pipe layout for G1 Bottom deck and Side deck generated. CM-SM Interface loads and Spring Thruster velocity requirements finalized. Angle Drogue chute load case for structural test firmed-up and G1 mass properties generated. Crew Module Service Module - Connect Disconnect System (CS-CDS) umbilical [CSU] plates with electrical and fluid connectors realised & functional development tests of CSU umbilical by pneumatic bolt release mechanism completed successfully. Low-Density Carbon Phenolic [LDCP] was chosen as the candidate material for the aft heat shield Thermal Protection Shield. Detailed characterisation for ablation and thermal performance was carried out.

Hypervelocity impact tests on simulated CM conical region for qualification of micrometeoroid and orbital debris [MMOD] protection shield is successfully completed at M/s TBRL, Chandigarh, and ballistic limit curves validated.

Crew Module sub-assembly delivered to VSSC for a structural test.

2.1.2 Separation System

Realisation of pyro thruster of ACS separation system is completed. Two development tests were carried out. Indigenous development & realisation of 1st set of rod end bearing is completed for the CM-CES separation system. Tensile (radial) and compression (radial and axial) tests are completed successfully. Three developmental

tests and TV-D1 hardware were realised for Grid Fin Deployment System. Hardware realised and structural test completed on CMF-SMF separation system hardware.

2.1.3 Up-righting & Buoyancy Augmentation system

Top PUF blocks of the buoyancy augmentation system are realised. Bottom PUF, block mould realisation, is in progress. A float system with Nylon material for an Up-righting system was realised for inflation trials, and trials were conducted. PDR for Crew Module Up-righting System (CMUS) is completed with a storage gas-based charging system.

2.1.4 TV/G1 Propulsion systems

Crew Module Propulsion System (CMPS) will be used during the re-entry phase for a nominal mission, and it will be operational in the ascent phase in case of an abort. Qualification tests of CMPS are planned in two phases. Phase-I qualification tests (7 nos. of hot tests) consisting of 6 nos. of sea level 100 N ablative thrusters. The Service Module Propulsion System (SMPS) consists of 5 X 440 N LAM engines and 16 X 100 N RCS thrusters. Propellant tanks & Gas bottle realisation for Test vehicle flight is completed. Vibration test of Crew Module propellant tank qualification hardware (22 L) completed. Flow components required for TV-D2 mission realised. Experimental analysis was carried out to study the impact of MMH on the thruster fire ply gasket and silica phenolic material. As part of 100N thruster qualification (ablative version), continuous & pulse mode testing for a cumulative duration of 165 s & 82 s, respectively is carried out. Detailed analysis is carried out.

2.1.5 Crew Module System Demonstration Tests (CM-SDM) for qualification of propulsion systems

1st hot test [Test-1A] of the Crew Module-System Demonstration Model (CMPS-SDM) was successfully completed at the New LAM test facility, IPRC, on June 21, 2022. Hot test with six nos. of sea level ablative thrusters carried out for a duration of 5 s.

CM-SDM Phase-I tests

2nd Hot test [Test-1B] with a duration of 636 s simulating the ascent phase abort profile was successfully completed on August 4, 2022.

3rd Hot Test [Test-1C] with a duration of 36 s simulating the ascent phase abort profile was successfully completed on September 21, 2022.

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4th Hot Test [Test-1D] with a duration of 88 s simulating the ascent phase abort profile was successfully completed on September 23, 2022.

5th Hot Test [Test-1E] with a duration of 130 s simulating the ascent phase abort profile was successfully completed at the New LAM test facility, IPRC, on September 28, 2022.

6th Hot Test [Test-1F] with a duration of 249 s simulating the ascent phase abort profile was successfully completed at the New LAM test facility, IPRC, on September 30, 2022.

7th Hot Test [Test-1G] for a duration of 582 s simulating the nominal de-boost/ re-entry with aero-dispersion was successfully completed at the New LAM test facility, IPRC on November 2, 2022.

Overall, Phase-I Qualification tests [7 Hot Tests] of CM-SDM are completed successfully.

2.1.6 Deceleration Systems & Air Drop Tests

Various types of parachutes will be housed in the apex region of the crew module, viz., Pilot, drogue, and main parachute. Design of all parachutes and mortars completed. Realisation of parachute till 1st unmanned flight completed. Towards qualification of the parachute system, Integrated Air Drop Tests and Rail Track Rocket Sledge (RTRS) tests are to be carried out. Total 13 nos. of integrated airdrop tests are planned to simulate main parachute extraction, deployment, and inflation conditions as in flight, as well as the simulation of clustered deployment of parachutes using mortar-deployed pilot chutes. It will also be used for structural qualification of the main parachute simulating qualification level load.

Out of 13 tests, three airdrop tests have been successfully completed towards qualification of the main parachute (with a diameter of 25 m) using aircraft. Rail Track Rocket Sledge (RTRS) tests [Phase-I] have been successfully completed towards qualification of ACS & pilot mortar/parachute. Drogue and Stabiliser chute drop test for verifying flawless unfurling of chutes from pack cover using aircraft completed at ADRDE. Integrated Main parachute Air Drop Tests [IMAT] with 2 parachute configurations [failure mode simulation] is successfully carried out.

Integrated Main parachute Air Drop Test (IMAT)

2.1.7 Crew Seat & Flight Suit

Crew seat modal & static analysis were done assuming rigid connection of deck with pallet and assumed honeycomb properties (same as the bottom deck). Structural Finite Element Analysis carried out for indigenous Crew Seat Bucket with welded configuration. Inward inspection of crew seat and flight suit completed at LPSC, Bengaluru.

2.2 Crew Module for Integrated Air Drop test [IADT]

Crew Module hardware realisation is nearing completion at industries. Parachutes are available. Pilot and Drogue mortar qualification is in progress. Avionics are ready. The helicopter attachment & separation plane connector scheme has been worked out. Measurement of downwash velocity under Chinook Helicopter using Ultrasonic wind sensor is firmed up. Drop altitude for stabilizer chute deployment validation test and flight Profile of Chinook helicopter for shield plate trials, stabiliser plate validation tests, trial sortie, and IADT have been worked out based on the discussion with the Chinook team.

2.3 Service Module [SM] for G1 Mission

2.3.1 Structure

3D finite element (FE) model generated for carrying out non-linear analysis of longerons along with FE & AE ring of the service module. Length of bolts, grip length of rivet and size & number of rivets were worked out for longerons mounting configuration in service module structure. Mass parameters computation completed. Fabrication of SM structure in progress.

2.3.2 Propulsion system

Updated propulsion layout with plumb line routing up to bottom deck worked out. Successfully completed qualification test on 100N radiative cooled thruster. Completed the assembly of 2 nos. of 100N thrusters with ground FCVs for injector characterisation test. Injector characterisation completed on 2 nos. of 100N radiative version thrusters. For the incorporation of the sensor for the measurement of propellant temperature, various schemes have been worked-out & finalized.

2.4 OM Avionics Systems

2.4.1 Avionics for Test Vehicle

The entire set [83 nos.] of CM avionics packages for TV-D1 Mission is handed over for assembly & integration activities after successful completion of T&E. Test & evaluation completed for avionics packages viz., Navigation Guidance & control

Handing over of TV-D1 Avionics packages

processor [NGCP], stage processing system [SPS] and Advanced telemetry system [ATS] stack. FRR completed for NGCP and Interface systems. Finalized Onboard Antenna location for S-band and Navic Antenna on CM and transfer antenna location on CMF (internal and external) after testing. Drawings CC is released.

Simulation models realised & testing completed. TV-D1 Crew module simulation input profile tests completed for Sequencing, Navigation and REX. System integration and initial calibration completed for mini-AINS. CES Checkout system realised and operational. CES instrumentation, power checks & sequencing checks were completed. Functional testing of CM location transmitter (GNSS Receiver + UHF Beacon) with LEO satellite is completed.

LEA deck with CES avionics

2.4.2 OM Avionics for G1 Mission

The systems are configured in Triple Modular Redundancy (TMR) with fail-safe philosophy. The design and configuration of the avionics system are completed and PDR is in progress. Package realisation is in progress. Software reviews completed and implementation in progress. Component requirement finalized to initiate procurement action for the realisation of simulation packages which are required to do various simulation tests. Revised Avionics Configuration for the G1 mission is worked out. LVHM would be in monitoring mode and CES in active mode. NGC system in quad configuration to meet the fail-op fail-safe requirement is being configured. The PDR document of Mission Computer and NGC is completed. QM model Radiation Dosimeter's humidity and EMI-EMC tests are completed. Telemetry and telecommand interfaces of AVPU is finalised. Software Quality Assurance Plan (SQAP) and Software Development Plan (SDP) of BVE and AIU packages were generated. NGC SRD document for G1 has been released.

2.4.3 Ground Stations and Data Relay Satellites

The detailed Mission Requirements (DMR) Document, describing the overall requirements of Gaganyaan regarding Direct-to-Ground (D2G) communications support from ESA ground stations finalized. Technical Implementation Plan (TIP) is in progress.

The requirement for Ship Borne Terminals for the ascent phase and orbit circularization firmed-up. A requirement note on Ship Borne Terminal (SBT) and Transportable Terminal (TT) requirements for the Gaganyaan mission comprising of Transportable

Terminals in Ships, Cocos island and Helical Antennas and associated communication equipment including VSAT terminals etc., are generated. Implementation Arrangement between ISRO and ASA has been signed by both parties for establishing and operating Transportable Terminal at Cocos Island. For Project Manager in Australia, the Request for Proposal (RFP) was sent to all three parties identified by Indian High Commission in Australia. Civil construction works for IDRSS-1 feeder station commenced at SCC premises, ISTRAC.

3. Development of New Facilities & Infrastructure

3.1 Second Launch Pad

Umbilical Tower (UT): Modification of liquid oxygen vent headers completed. Modifications towards the introduction of differential pressure transmitters in the terminal filter circuit for hypergolic propellant circuits are completed. Qualification & testing of the system completed. Bubble lift: Erection of car body, machine room cable tray trunking & earthing completed. High-speed Trials of bubble lift carried out with a temporary power supply. Final commissioning works are in progress. Crew Access Arm: Trial suiting of **Crew Access Arm** with Supportive structure at UT/SLP completed.

Bubble lift erection at UT

LTR-G Building

White room: Configuration is finalized.

Launch Vehicle Terminal room (LTR-G):

Civil work- Internal painting completed. AC system works completed.

External electrification: UPS Cabling works completed.

Internal electrification: Wiring completed.

3.2 First Launch Pad

Towards readiness of the First Launch Pad for TV-D1 flight, Interface verification of Launch Pad Interface Ring with base shroud elements like LHRS, RFDS, LMP sensor brackets, check out cables routing over LPIR etc., completed. Remote Valve enclosure (RVE) modification completed. Umbilical interface modification works on FLP-UT Completed.

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3.3 Orbital Module Preparation Facility (OMPF)

Gantry girder erection completed. Erection of modular wall panel at SM & CM bay completed. Erection of EOT cranes completed at MAL bay, SM bay & CM bay. Assembly tower fabrication work completed. Erection of modular wall panel at CM & SM bay completed. Sliding door erection completed in CM bay.

Orbital Module Preparation Facility [OMPF]

3.4 Gaganyaan Control Facility (GCF)

External façade & painting completed; VIP lounge, conference hall, and lobby work completed. Electrical conduiting and AC ducting completed. Entrance facade glazing works and acrylic lettering completed. GCF to SCC and GCF to LCC-II hard line laying is completed. Hard lines laying from LTRG to SVAB are in progress.

Gaganyaan Control Facility [GCF]

3.5 Crew Module vibration test facility

Interface ring realised. Match-mate checks & inspection completed. Interface ring vibration characterisation with shaker system & load testing completed.

3.6 Stage Preparation Building (SPB)

Test vehicle (L40) engine liquid stage powering-on, ambient checks, engine re-assembly, free gimballing Trial suiting with thermal boot carried out.

Test Vehicle (L40)

4. Environmental Control and Life Support System

4.1 Thermal & Humidity Control System (THCS)

THCS Phase – 2 Integrated Test at Industry was carried out. 18oC cabin temperature and 65% cabin RH achieved. System level design of Thermal and Humidity Control System validated. Systems Engineering of THCS in the Service Module is completed. The design of radiator cooling jacket, multipurpose vent valve, diverter valve and condensate collection tank are completed. Characterisation and configuration for the condensation heat exchanger are finalized.

THCS Integrated Test at Industry

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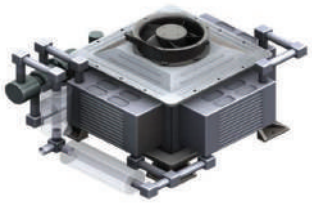
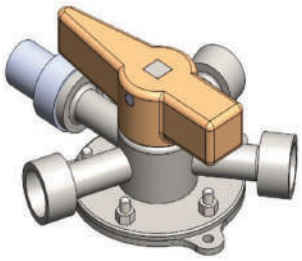
Condensate collection tank



Condensing Heat Exchanger

Multi-Purpose Vent Valve



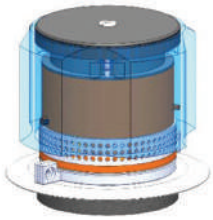
Diverter Valve

Cabin liner

Manual Condensate Pump

4.2 Cabin Pressure Control System (CPCS):

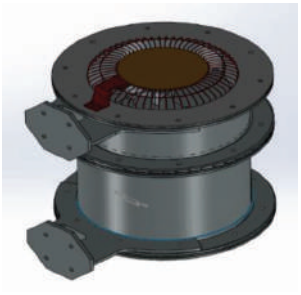
Design completed for Flight suit pressure regulator.



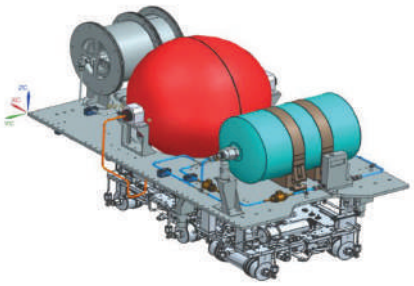
Flight suit pressure regulator

4.3 Human Metabolic Simulator (HMS):

3D model of humidifier assembly completed and drawings generated.



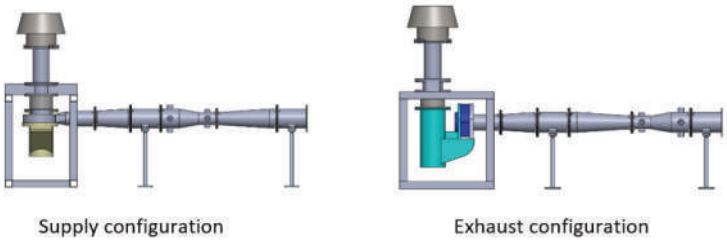
Humidifier assembly of HMS



HMS Engineering Model

4.4 Cabin ventilation Unit (CVU):

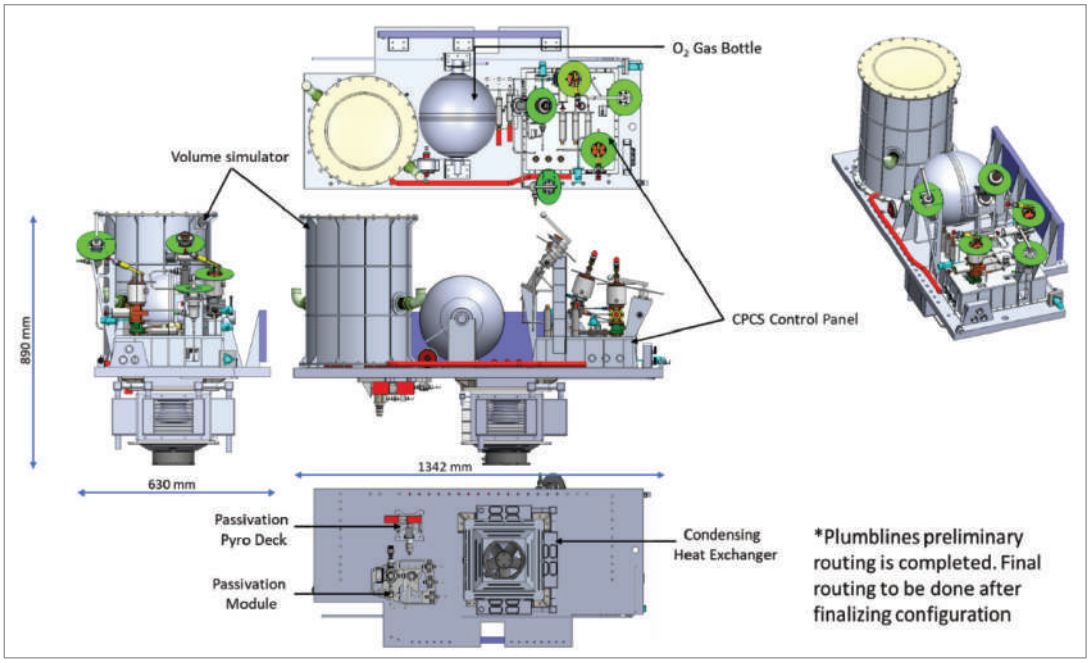
Configuration of CVU test set up and seals for a manual valve is completed, and drawings are generated.



CVU Test set up

4.5 ECLSS Systems Engineering:

Accommodation of EMS, generation of interfaces for ECLSS chamber, vacuum feed-throughs, electrical feed-throughs and ECLSS deck completed.



ECLSS assembly on deck

5. Human Factors Engineering

Human Factors Engineering is targeted towards Occupant protection, Crew comfort, Crew cabin Ergonomics assessment with Digital Human Modelling procedures, generating acceptable limits on crew physiology during various mission phases, and devising methods for physical strength assessment of crew to perform tasks within the module. In addition, steady progress has been made in the area of Micro Meteoroid Orbital Debris (MMOD) protection analysis and testing, an activity identified to ensure crew safety and occupant protection in space.

Range of motion of Crew in microgravity environment in a neutral g posture has been completed to study the feasibility of crew suit donning and doffing operations in space. While on the launch pad, entry of crew inside the crew compartment has been examined in detail after investigating various crew entry procedures adopted in various human space flight missions around the world. After interaction with the system engineering team, an elegant method for crew entry has been identified, meeting ergonomic requirements. Investigation of various software tools for Musculo

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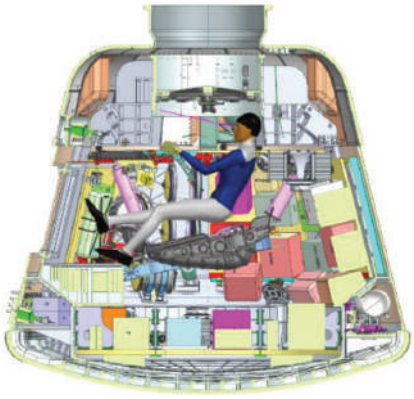
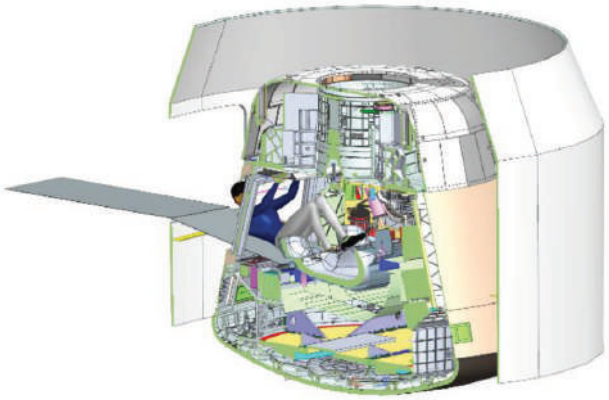
skeletal modeling of the crew has been completed, and a versatile software tool has been identified and action initiated for purchase. Preliminary musculoskeletal models have been generated to ze and understand a few basic human arm movements for modeling more complex crew movements. In an effort to establish state of the art Human Factors Engineering Laboratory within HSFC, visits were made to multiple private and Government units involved in bio-mechanics for finalising the technical specification of different bio-medical equipment. Accordingly, tendering actions are in the advanced stage for procurement of strength measuring equipment and an Inertial Measurement Unit (IMU) based motion capture system.



Digital modelling of Crew in micro gravity neutral g posture

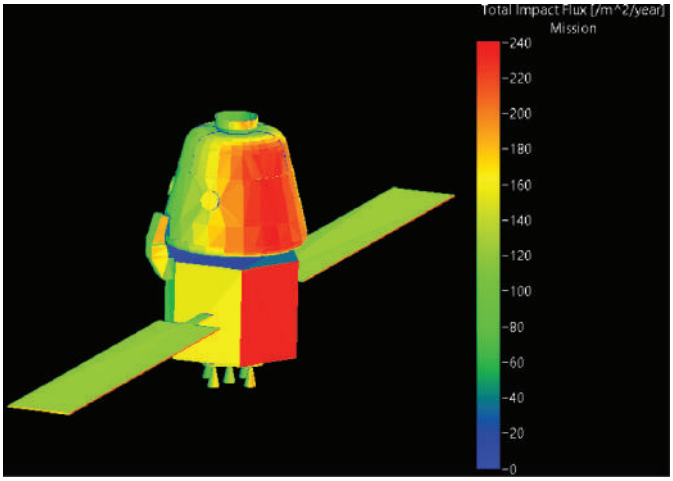


Digital modelling of Crew Ingress into Crew Cabin

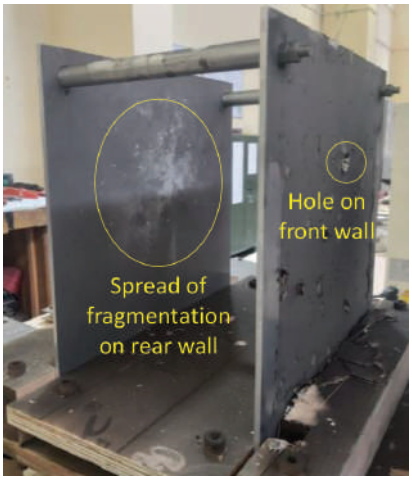
In order to improve the situational awareness of the crew during the flight, display tools such as an effective module attitude indicator system and ready reckoning impact point predicting tool has been developed. After a detailed discussion with Astronaut Designates (AD), the suggestions offered by AD's on attitude indication methodology are being incorporated.

Significant progress has been made with regard to the analysis and testing of MMOD shields for the Gaganyaan Orbital Module. Instead of a conservative design methodology, a more realistic analysis using a dedicated software ESABASE, procured from ESA under license, has been used to optimise the mass of shielding required to meet the acceptable specified debris impact risk levels. Taking into consideration the limitations of the only Hyper Velocity Impact (HVI) Facility in the country, novel methods in the selection of shielding configuration samples and impact projectile diameters were generated without sacrificing the overall objective of validating the effectiveness of the shield in withstanding the penetration of the Hyper Velocity projectile. Specimen required for testing were fabricated in coordination with CMSE/ VSSC. HVI tests on different shielding specimen targets were conducted with a single

stage gun at 1.6 km/s and two-stage light gas gun at 5 km/s. Further test program is in progress. As a developmental effort, a working scheme and model for detecting MMOD impact in space has been developed and successfully demonstrated. Scaling up of the working model to an Orbital module sized application has been taken up.



ESABASE analysis indicating debris flux on OM



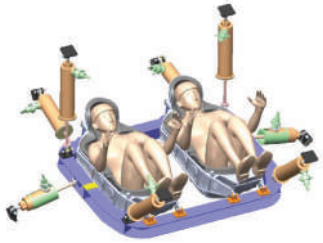
Whipple Shield Test specimen - Post HVI test at 5 km/s

Activities are coordinated for the realisation of re-entry thermal protection system for the Gaganyaan Crew Module and thermal protection system mass simulator in the form of cork phenolic and rubberized cork for TV-D1 CM.

Mission requirements and mission planning for the forthcoming TV-D1 mission to demonstrate Crew Escape System capability in transonic Mach number have been completed. Mission sequencing activity for the descent mission of the Crew Module in the TV-D1 mission has been completed considering nominal, off-nominal, and various failure case scenarios. A mission sequence has been provided for detailed mission simulation activity. Studies to improve the stability of the parachute crew module system were initiated using an in-house developed 15 Degree of Freedom simulation package. Study results have been published in Symposium on Applied Aerodynamics and design.

5.1 Crew Seat Developement

The anthropometric design of the seat has been carried out, and structural design is under progress. The pallet frame design for H1 and G1 missions is completed, and upgrades are being implemented. Implementation of the ECLSS system, along with a half-humanoid robot on a pallet frame is being studied.



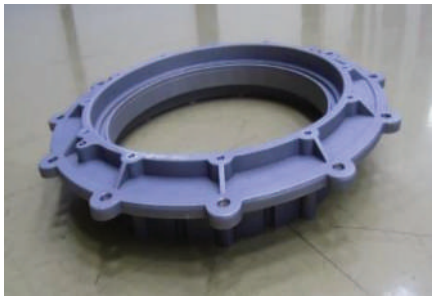
H1 Crew Seat Assembly

2.6 Gaganyaan

The design of the mechanism for crew seats involving load estimation, attenuator modeling and space optimization according to global injury criterion is in progress. Different types of attenuating elements are being numerically analysed and experimentally characterised. Critical design of attenuator components, including pyro device and attenuating eleent is in progress. Along with design activities, the following collaborations are being pursued: ARAI (for the development and testing of an alternative attenuator mechanism), IITM (for water impact testing), and NAL (for mechanism performance testing).

5.2 Indigneous Viewport Design

Extensive conceptual studies and theoretical simulations are being carried out on the preliminary configuration in different domains like thermo-structural, thermal and structural, seating and contact analysis of seals, optical analysis etc, to finalize the design. Aerodynamic studies are being carried out in hypersonic wind tunnel testing facility to finalize the configuration of viewport interface with the Crew Module structure. 3D printing of various components was completed to validate the assembly sequence and interfaces of the viewport.

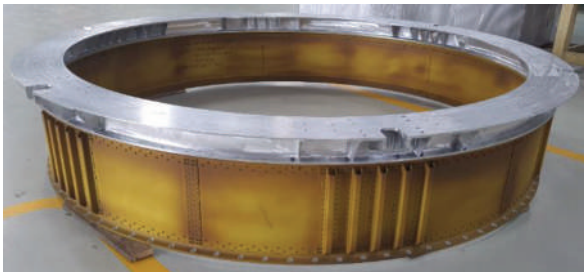


3D printed pressure pane holder

For the testing of the parachute deployment sequence and parachute performance during the Crew Module re-entry and touch-down phase, 4 Crew Module-like structures that simulates the mass and CG of the human-rated Crew Module in the Gaganyaan mission are being realised by Indian industries with a welded and fastened construction. 2 such Crew Module structure are nearing completion of realisation at industries in Chennai and Hyderabad.

5.3 Simulated Service Module Realisation for Test Vehicle Mission

For the Test Vehicle (TV) missions, the simulated Sevice Module (SM) structure and fore-end ring have been realised and delivered.For the system level acoustic emission testing of the Crew Escape System, a High Altitude Escape Motor (HEM) simulator has been realised. For the static testing of the Service module propulsion system, the tank simulator structure has been realised.



Simulated SM for TV missions

6. Assembly System Testing and Recovery

In February 2022, Chairman ISRO inaugurated Samakalan Lab at HSFC, inaugurated the Flight Harnessing Activities for TV-D1 CM, and witnessed the Prototype Testing of Assisted Separation Force (ASF) Connectors in flight condition of CS-CDS.

TV-D1 CM Checkout System Handover with Director, HSFC

TV-D1 CM Checkout System Hardware Handover ceremony was carried out at the vendor's facility in the presence of the Director, HSFC, in July 2022.

In October 2022, Chairman ISRO inaugurated the CHES activities of TV-D1 CM at AITF-2, ISITE, in the presence of the Director, URSC & Director, HSFC. Chairman, ISRO also inspected the Flight Harness of TV-D1 CM, MGSE for TV-D1 CM & Fabricated Flight Brackets for TV-D1 CM at AITF-2, ISITE. TV-D2 CM Checkout Rack Harnessing was inaugurated by Director, HSFC, in December 2022 at the vendor's facility.

TV-D1 CM flight harness at AITF-2, ISITE

A prototype of a Toroidal buoy for Crew Module Recovery Activities has been realised by the vendor.

Prototype of Toroidal Buoy

Crew Module Recovery Module (CMRM) is under fabrication at the vendor's facility, with delivery expected by the end of December 2022.

CMRM being realised at vendor's facility

7. Safety, Reliability & Quality

7.1 Human Rating and Certification

A human rating certification mechanism is established, and the system is in place. The Human Rating Requirements (HRR) for Gaganyaan and the Human Rating Certification Plan (HRCP) are approved and released after due deliberations in the Human Rating Certification Board (HRCB).

The enterprise development software (GRTC) to automate the certification process is implemented and accessible through the intranet homepage of all centres. The Gaganyaan Product Tree, containing systems and subsystems identified for certification is implemented in the GRTC.

7.2 Probabilistic Risk Assessment (PRA)

Played a lead role in equipping all Centres to carry out PRA studies for Gaganyaan. Organised workshops and released guidelines documents for carrying out PRA studies. Developed an integrated framework for carrying out PRA studies for the Gaganyaan mission. PRA studies were carried out for the Thermal and Humidity Control System (THCS).

7.3 Acceptance tests for procured items

Participated in the inward inspection of the following procured items and ensured compliance to the specification given in the inward inspection manual. (i) 12 sets of flight viewport (ii) 12 no's crew seat assembly (iii) 3 no's space suit and accessories.

7.4 Quality Assurance activities

Integrated Air Drop Test (IADT)

As part of the Quality Assurance activities of the IADT structure (Apex sub-assembly, dome sub-assembly, and main assembly) and SM simulated structure, carried out the following activities.

Certification of raw material for IADT

Reviewed and cleared the raw material process plan and issued Raw Material Certificate (RMC). Carried out pre-dispatch inspection to ensure an adequate standard for material specification.

QA of manufacturing process

Reviewed the manufacturing process plans of hardware structural components to ensure correct manufacturing route the presence of adequate machining allowance at each stage. Review of QC plans to assess the correctness of the instruments proposed to measure the features.

Avionics and Software Systems

Verification of baseline documents (FMR, ATS gain scheduling, channel allocation, powering scheme, grounding scheme & pyro circuits, verification of harness details and electrical integration document, and verification of power system and NGC checklist for Phase -1. The Software QA plan for TVD2 Crew Module checkout software and a study report on additional features in ISSS over ISPD were released.

FMECA Studies

FMECA Studies were carried out for the Thermal and Humidity Control System (THCS), Cabin Pressure Control System (CPCS), Air Revitalization System (ARS), and Viewport.

Post evaluation study of Dosimeter

Carried out the post-test evaluation of the active dosimeter for all environmental tests. Identified and resolved the major non-conformances during testing, improving the overall quality and reliability of the product.

Crew Training Simulators (CTS)

Released CTS QA plan and CTS Software QA plan. Conducted Test and Evaluation (T&E) of the display console identifying the consistency of display parameters w.r.t test cases.

8. Crew Training

Gaganyaan Mission-specific training commenced in India after the successful completion of Generic space flight training of Four Indian astronaut candidates at Gagarin Cosmonaut Training Centre (GCTC), Russia. For training the crew, Astronaut Training Facility (ATF) was constructed and commissioned at Bengaluru. The training

Astronaut Training Facility (ATF)

2.6 Gaganyaan

curriculum & evaluation criteria were finalized for the mission-specific training. The Mission specific training includes theoretical courses in engineering disciplines and training on Gaganyaan flight systems. The training also covers Aero-medical training & Fitness and Recovery & Survival training as part of the curriculum. Practical training on Simulators and Flight procedures will also be imparted.

The theoretical courses on engineering disciplines such as Basics of Spaceflight, Propulsion, Aerodynamics, and courses on Launch Vehicles and Spacecraft were conducted. Physical training, Yoga, Aero-medical training, and Flying Practice are being conducted as part of the training curriculum. Virtual Reality & Independent Training Simulators were realised for familiarisation with Crew Module systems. The courses on Gaganyaan flight systems are being conducted. The first semester of Crew training is successfully completed.

Present status of crew training:

- 39 Weeks (600 Hours) of Crew Training Activities have been completed in First Semester
- 218 Lectures by 40 Faculties (from IISc/ISRO)
- 75 Physical Training Sessions
- 3 Study Visits (ISITE/ISTRAC/IISc)
- 2 Flying practice (12 hours)
- 2 Medical evaluations, 2 Course evaluations

8.1 Crew Training Simulators

Crew Training Simulators identified for the Gaganyaan mission are. Independent Training Simulator (ITS), Virtual Reality Training Simulator (VRTS), Dynamic training Simulator (DTS), and Static Mock-up Simulator (SMS) to prepare the Crew for handling all the nominal and off-nominal scenarios of mission situations. These are in various phases of realisation.

8.1.1 Independent Training Simulator (ITS)

ITS is a tabletop simulator primarily aimed at familiarization of the Crew with the Crew control interface, both electrical and mechanical. It necessitates a similar user interface as that of the Crew Module, such as a Display system, pages, alerts, and control buttons. It incorporates procedural training for various crew activities.

Independent Training Simulator Set-up

The four components of the ITS Viz., Simulation environment and hardware interface system, Simulation system, Mission control console, and Trainer console have been realised, and crew familiarization sessions were conducted.

8.1.2 Virtual Reality Training Simulator (VRTS)

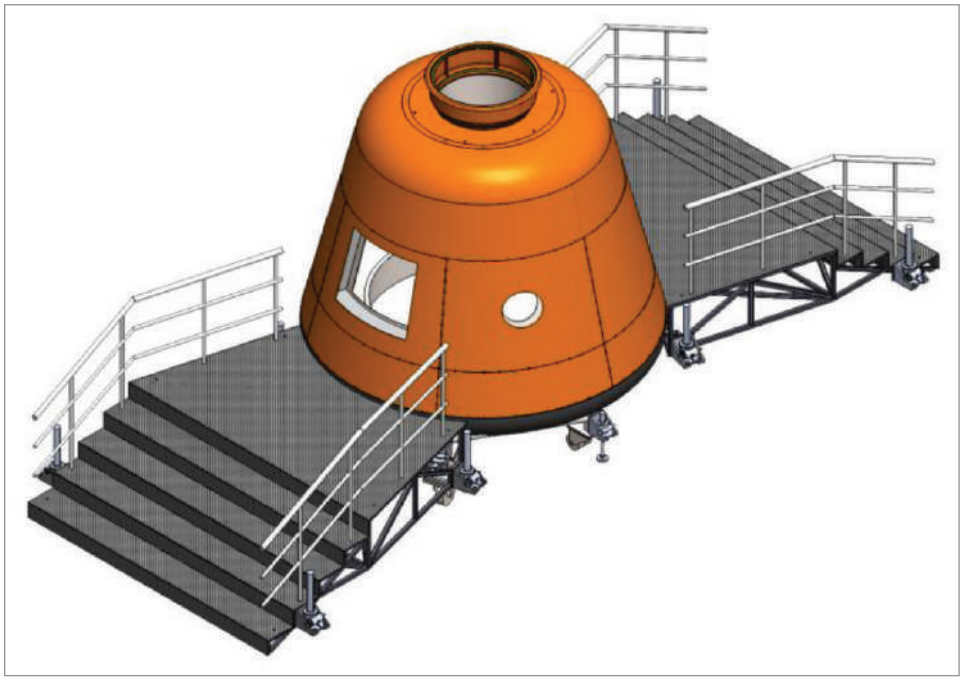
The first version of the Virtual Training Simulators is developed and deployed. In Gaganyaan, using VR simulators, astronauts were familiarized with the interiors of the Crew Module, front-end electronics hardware, display monitors and the location of different elements inside the Crew Module. The simulator is realised using a VR headset with software programmed in it and a hand controller to locate the devices inside Crew Module. Astronauts have virtually interacted with the switches and control panels inside the Crew Module and read the real-time data on the displays.

Typical Virtual Environment

2.6 Gaganyaan

8.1.3 Static Mock-up Simulator (SMS)

The static Mock Up simulator is under realisation. SMS provides a close to realistic ambiance and acquaintance with the Gaganyaan-CM, including the distance and approach estimation of the crew control buttons and displays systems. The available space for any crew activity will be the same as that of an actual CM. It requires the crew module mockup with every component like Avionics, ECLSS system, CPCS system, DRDO systems, etc. in the habitable area placed in exact congruence to that of the flight crew module for the near-real experience of the crew on the ground.



Static Mock-up Simulator

8.1.4 Dynamic Training Simulator (DTS)

DTS provides the signature of motion sensations expected to be felt by the crew during the actual flight. It trains the crew-trainee for audio and dynamics experience such as jerk, vibration, acceleration, body rates and shock during various phases of the mission such as stage separation, parachute deployment, touchdown and CES trigger events. It incorporates the Stewart platform and possibly other vibration/actuation platforms for providing dynamics perception to the crew trainee. DTS shall consist of a 6DoF platform, VR subsystems, Simulation system, Hardware interface system, Haptic full body suit and Trainer console. The realisation of DTS has been initiated.

9. Development of human centric systems

Meetings

1) DRT HCP (12 to 16) meeting was held to review the following:
   a. Sensory evaluation report for space food
   b. PDR of wearable textile belt configuration of Bio vest
   c. QTP/ATP of Passive dosimeter
   d. QTP/ATP of Emergency survival kit
   e. Bio vest sensor configuration and ECG data processing
   f. Revised food menu and menu options
   g. The batch concept for the chemicals for the Desalination kit

2) MCC meetings were held with all DRDO labs for updating schedules and for revision of MoU.

3) DLJ, DEBEL, and INMAS non-metallic materials were reviewed in the non-metallic materials committee.

Testing

4) Inward inspection of 5 nos of stowage bags from CNES, France completed (1 Food kit, 2 Hygiene Kits and 2 Medical Kits).

5) A depressurization test was carried out in the Industry for Emergency Survival kit (ESK).

Emergency Survival kit

6) Fabric and Velcro Samples for outgassing and flammability tests were received from DRDO, and testing was completed at VSSC and URSC.

Crew training

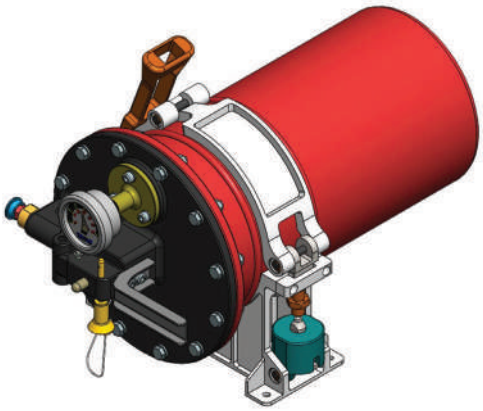
7) Received Crew training course material from DRDO labs.

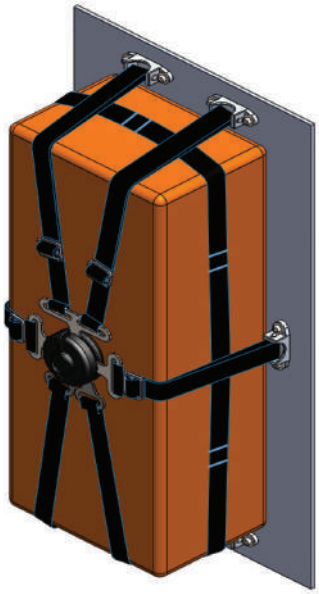
8) Received two nos. of Bio vest in latest configuration for CTS from DEBEL.

9) Received one no of Emergency survival kit for Crew training from DEBEL.

Interfaces

10) Fire Suppression System: Quick action mechanism to mount the FSS in the crew module is completed.

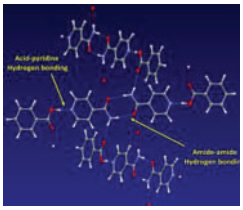
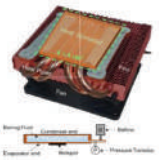




11) ESK: Belt configuration for mounting the ESK in the crew module is finalised.

10. Development of Microgravity payloads

There are five microgravity experiments recommended for an uncrewed flight of Gaganyaan. The experiments were evaluated on the basis of novelty, science objectives, maturity level, and suitability to autonomous operations.

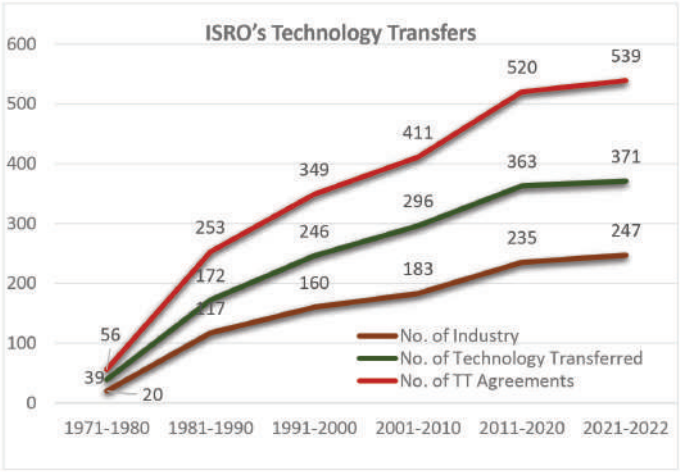
Sl. No	Institute/University	Proposal	Experiment Setup
1.	Indian Institute of Space Science and Technology (IIST), Thiruvananthapuram	Spaceflight-induced changes in kidney stone formation in Drosophila melanogaster	
2.	Tata Institute of Fundamental Research (TIFR) – Mumbai	Investigating effects of microgravity on SIRT1 mediated control of cellular and organismal physiology	
3.	CSIR-Indian Institute of Chemical Technology (IIICT) – Hyderabad	Co-crystallization of API-API and API-Nutraceuticals under Microgravity conditions	
4.	Indian Institute of Technology (IIT) – Patna	Passive two-phase heat spreader for hotspot mitigation in the microgravity of space	
5.	Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) – Bengaluru	Interfacial Instabilities in micro-gravity conditions	

2.7 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, and MoU with government entities & other reputed institutes for sharing technology know-hows.

1. Technology Transfer:

ISRO has transferred more than 363 technologies to around 250 industries across India. As per the recent Cabinet approval responsibility of transferring technology to industries lies with NSIL (the commercial arm of DOS). Accordingly, ISRO has entered into an MOU with NSIL for the transfer of ISRO's technologies.

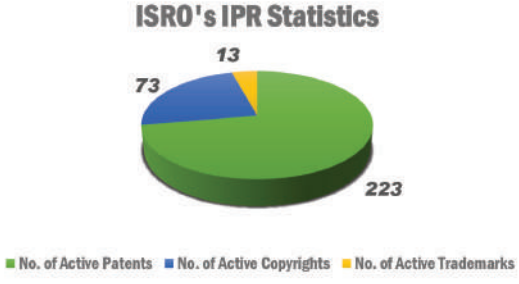


Further, ISRO has transferred around 78 technologies to M/s NSIL for transferring to Indian Industries for commercialization, societal application, and regular production. Based on the market potential and industry demand, NSIL is transferring these technologies to industries through an MoU.

ISRO has compiled the Interest Exploration Notes [IENs] of more than 165 active technologies available across ISRO centres and published in the ISRO website.

2. Intellectual Property Rights:

ISRO has around 223 active patents, 73 nos. of copyrights, and 13 nos. of trademarks. During the reporting period, around 21 patent applications and 3 copyright applications are filled, 43 fresh patents were granted, and active patents were renewed. Presently, 87 nos. of patent applications are under



various stages of examination, and 21 are undergoing drafting by the patent attorneys before their eventual filing at the patent office. Internationally, one PCT application has been granted. ISRO's IPR processing online, and the same is made operational. A new IPR portal has been developed to process the IPR proposal from ISRO centres online and also create online ISRO's active IPRs have been updated and made available on the ISRO website.

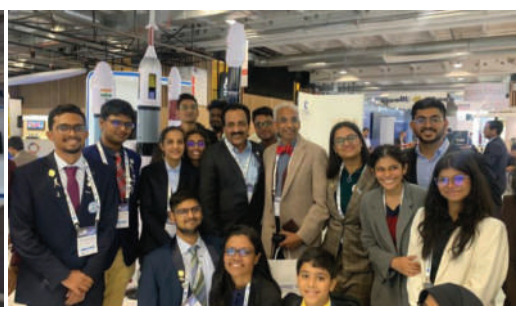
3. Industry Interface

3.1 Bengaluru Space Expo -2022 (BSX):

7th edition of Bengaluru Space Expo (BSX) was organized during September 5 -7, 2022, at BIEC, Bengaluru, Karnataka. It was an exhibition cum technical sessions, and more than 250 industries across the globe participated and showcased their capabilities & products. Chairman, ISRO / Secretary, DOS inaugurated conference & exhibition in the presence of Chairman, IN-SPACe and CMD, NSIL, Chairman, CII, and other senior officials from various space agencies. More than 125 speakers from various industries, startups, space agencies, and academia participated.

3.2 International Astronautical Congress (IAC-2022):

International Astronautical Congress (IAC-2022) was organized in Paris, France during September 18–22, 2022. ISRO along with NSIL & IN-SPACe, participated in various technical sessions, and bilateral discussions with international space agencies & industries and also established an exhibition pavillion by showcasing achievements and plans of Indian space programmes. DOS also facilitated for participation of six



2.7 Capacity Building

Indian space startups in the event. The Secretary, DOS / Chairman, ISRO, and senior officials of DOS participated in the event.

3.3 India Space Congress 2022:

The first edition of the India Space Congress 2022, a three-day confluence organised by SatCom Industry Association (SIA-India) in association with ISRO, deliberated on the startup community, technology & business models, business opportunities, growth & market access, standardisation, policy and regulatory landscape in the space sector. It witnessed 650 delegates, 180 speakers, and 35 sessions over 30 nationalities.

3.4 Technology Transfer Conclave:

Space reforms mandate NewSpace India Ltd (NSIL) to transfer the technologies developed by ISRO to the Indian industry for commercial use. For the last two years, 78 technologies were transferred to NSIL for commercialization. To promote this further, a technology transfer conclave was organized on June 27, 2022, at ISRO Head Quarters, Bengaluru. Thirty-six industries participated, and 11 ToT agreements were exchanged between the industry & NSIL. Sri S Somanath, Secretary, DOS, inaugurated the event and addressed the participants. Sri D Radhakrishnan CMD, NSIL, Sri M Sankaran, Director, URSC, Smt. Sandhya Venugopal Sharma, Additional Secretary, DOS, and other officials from DOS & ISRO also participated.

3.5 Indian Space Association (ISpA) Conclave:

A pivotal agency for connecting space startups, industry, and the governmental agency has organized a conclave to discuss emerging trends in the space domain. Domain experts from ISRO shared their experience and current developments.

3.6 SpaceTech Innovation Network (SpIN) Workshop

Indian Space Research Organisation (ISRO) and Social Alpha signed an MoU to launch SpaceTech Innovation Network (SpIN) on December 6, 2022, which is India's first dedicated platform for innovation curation and venture development for the burgeoning space entrepreneurial ecosystem. Secretary, DOS / Chairman, ISRO launched the platform on December 6, 2022 at ISRO Head Quarters. SpIN is a one-of-its-kind public-private collaboration for startups and SMEs in the space industry. This novel partnership is a significant step forward in providing further stimulus to India's recent space reform policies. It will work towards identifying and unleashing the market potential of the most promising space tech innovators and entrepreneurs in India. It will primarily focus on facilitating space tech entrepreneurs in three distinct innovation categories: Geospatial Technologies and Downstream Applications; Enabling Technologies for Space & Mobility; and Aerospace Materials, Sensors, and Avionics.

More than 150 space startups, members from ISPA, SIA, DPIIT, and senior officials from ISRO centres participated in the programme. As part of launch programme, technical workshops on various topics was organized to create awareness among participants on opportunities for startups in the space domain.

2.7 Capacity Building

4. Student Outreach Programmes:

4.1 Yuva Vigyani Karyakram-2022 (YUVIKA-2022):

The YUVIKA 2022 was an offline residential training programme conducted from May 15-28, 2022. Around 152 students from 36 States/UTs across the country were trained in the space domain at 5 centres of ISRO viz, VSSC, Thiruvananthapuram, URSC, Bengaluru, SAC, Ahmedabad, NRSC, Hyderabad and NESAC, Shillong. The students were taken to visit SDSC SHAR after ten days of training at the respective Centres. The programme includes teaching theory as well as practical demonstrations of scientific concepts, interaction with eminent scientists, lab/facility visits, sky gazing, robotic activities, and some co-curricular activities.

Around 1 lakh students applied for the programme online, out of which 152 students were selected based on their academic scores, online quiz, and achievements in other co-curricular activities.

4.2 Space Tutor:

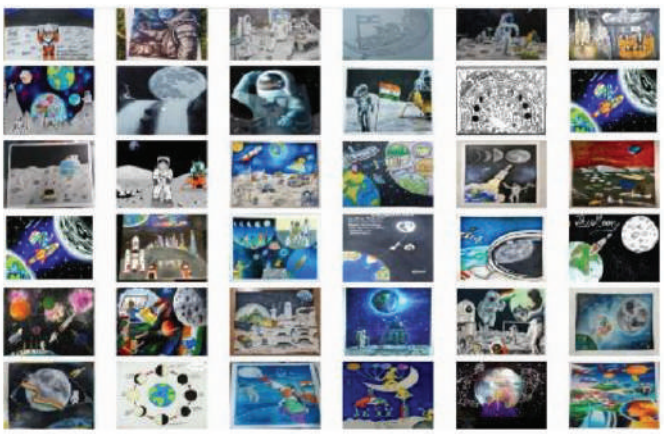
Space Tutor is a student outreach programme, which connects students, academia, space enthusiast, etc., with ISRO through NGEs/startups/Institutions. It will enable promotion space education & STEM activities across the student community. 56 NGEs/ Institutions/Startups from different states of the country have registered with ISRO to promote the space education nook & corner of the country.

4.3 ISRO's Virtual Space Museum SPARK:

ISRO developed a virtual space museum with digital content pertaining to various ISRO missions in an interactive manner. The virtual space museum "SPARK" was launched by Secretary, DOS / Chairman, ISRO on September 10, 2022 for public use. The platform hosts several documents, images & videos related to ISRO launch vehicles, satellites, and scientific missions.

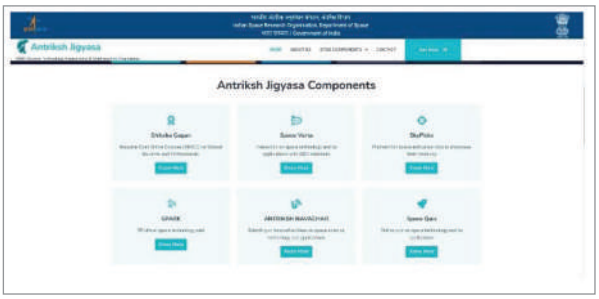
4.4 International Moon Day:

As part of the international moon day celebration, ISRO organized online painting/drawing and Quiz competition for school students of class 8th to 12th standard from July 6-19, 2022.



2.7 Capacity Building

4.5 Antriksh Jigyasa Portal:



ISRO developed a Antriksh Jiayasa online portal to provide e-learning on space science, space technology, and space applications. Secretary, DOS / Chairman, ISRO has launched the portal on November 14, 2022 for public access. Major components of Antriksh Jiayasa are Shiksha Gagan, Space Varta, Skypicks, Antriksh Navachar, Space Quiz, etc.

4.6 National Conference & Exhibition on Akash Tattva:

ISRO took a lead role in organizing a national conference & exhibition on "AKASH TATTVA" along with 6 S&T Ministries/Departments. The event was hosted by ISRO at IIRS, Dehradun. It is the first in a series of "Pancha mahabhoota" conferences being planned this year as part of the "Sumangalam" campaign. The "Akash Tattva-Akash for life" national conference was organized from November 5-7, 2022. Dr. Jitendra Singh, MoS, inaugurated the conference in the presence of the Secretary, DOS / Chairman, ISRO, Chief Minister of Uttarakhand, and secretaries of S&T Ministers / Departments.

5. Human Resource Development:

5.1 ISRO Technical Training Programme (ITTP)

ISRO signed an MoU with the Ministry of Skill Development & Entrepreneurship (MSDE) on April 27, 2022, for organising ISRO Technical Training Programme (ITTP). The programme is intended to impart skill development training to the technical staff of ISRO at various technical facilities of National Skill Trainings Institutes (NSTIs) across the country under MSDE. The MoU was signed by Secretary DoS / Chairman ISRO and Secretary MSDE.

Based on the MoU, ISRO has signed an agreement with six NSTIs, viz. NSTI Bengaluru, NSTI Chennai, NSTI – Mumbai, NSTI – Thiruvananthapuram, NSTI –Ramanthapur, Hyderabad, and NSTI – Vidyanagr, Hyderabad. A total of 13 ITTP programme have been conducted at five NSTIs by imparting training to 250 Technical staff from various ISRO Centres.

5.2 Management Development Programme:

Capacity Building Commission (CBC), in association with STI-CB cell, PSA's office & ISRO, has launched a Leadership Training Programme for 32 scientists from 8 science ministries. The training programme was organized from September 27-30, 2022. ISRO has taken the lead in hosting the programme.

The CBPO team, along with CBC team, visited major ISRO centres and interacted with various levels of scientists to obtain the training domains for preparing the annual capacity-building plan.

2.7 Capacity Building

6. RESPOND

6.1 Introduction

Academic Interface is one of the most important activities of CBPO Capacity Building and Public Outreach [CBPO] office at ISRO Headquarters, and it aims at encouraging joint collaborative research with academia/Labs/institutes and establishing the Knowledge/incubation/research etc. Centres across the country.

Recognising the need for a broader academic interface with institutions across the country, a series of capacity-building initiatives have been taken up to further strengthen the involvement of academia for ISRO programmes. These initiatives include R&D Projects (RESPOND Basket); Space Technology Cells (STCs); Regional Academic Centres for Space (RAC-S); Space Technology Incubation Centres (S-TICs); Centre of Excellence (CoE) at IISc; Satish Dhawan Centre for Space Science (SDCSS) at the Central University of Jammu; collaboration with Centre for Nano Science & Engineering (CeNSE) at IISc and ISRO Chairs.

Sponsored Research: ISRO started the RESPOND (Sponsored Research) programme in the 1970s with the objective of encouraging academia to participate and contribute to various Space related research activities. Under RESPOND, projects are taken up by the faculty of Universities/Academic Institutions in the areas of relevance to the Space Programme. Under this programme, 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. RESPOND programme aims to enhance the academic base, and generate quality human resources and infrastructure at the academic institutes to support the Indian Space programme. The research studies are expected to be directed towards some of the future Space activities, which would be a good supplement to various missions undertaken by ISRO.

ISRO has also set up nine Space Technology Cells (STC) at premier institutions like the 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.

With an aim 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, ISRO has set up 6 Regional Academic Centre for Space (RAC-S) in the country.

These 6 (RAC-S) have been established at MNIT, Jaipur (Western region), Gauhati University, Guwahati (North-Eastern Region), NIT Kurukshetra (Northern Region), NITK Surathkal (Southern Region), IIT(BHU) Varanasi (Central Region) and NIT Patna (Eastern Region). These RAC-s are inculcating the scientific temperament in the student community and also providing them with an opportunity to work in the advanced fields of research. RAC-S also facilitates and engages other institutes of excellence in the region to take part in capacity building, awareness creation, and research & development activities.

The collaboration with the 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.

With an aim to pursue advanced research in the areas of materials, especially on non-classical continuum mechanics and Geometric and data-driven models for space applications Centre of Excellence (CoE) on "Advanced Mechanics of Materials" has been set up at IISc.

In order to cater to the emerging Geospatial and Space technology requirements for the development of the region, Satish Dhawan Centre for Space Science" has been established at the Central University of Jammu, Jammu. Research and development related to space science, space-based disaster management, technologies for the development of the region etc., is the prime importance at the centre.

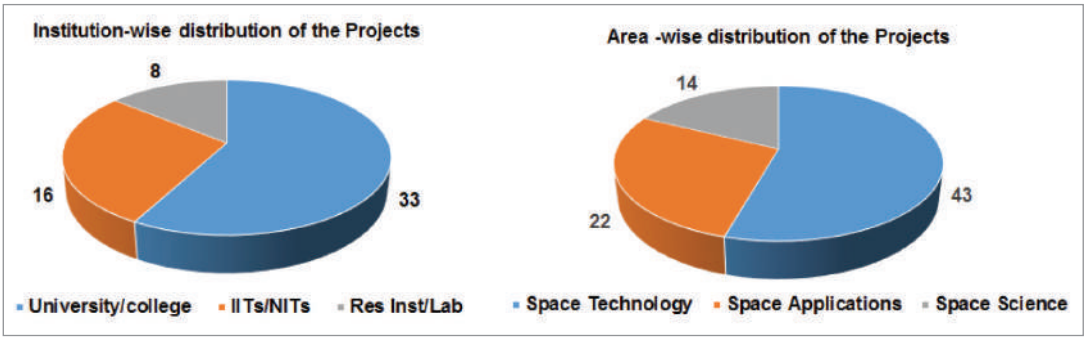
Also, under RESPOND, support is provided towards national/ international conferences focused on space activities or connected to the ISRO's missions/ programmes/ objectives, which are conducted by recognised universities/ Institutions/ Agencies / Industries on the themes of mutual interest.

6.2 Activities

During the period, RESPOND supported 26 New Projects, 43 ongoing projects, R & D activities of nine Space Technology Cells, and six Regional Academic Centre for Space. During the year, 34 sponsored projects have been successfully completed. Scientific publications have emerged out of these projects apart from fulfilling the objectives.

During the year, 33 Universities/Colleges, 16 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 (43) followed by Space Applications (22) and Space Science (14).

2.7 Capacity Building



Space Technology Cells: ISRO has also set up nine Space Technology Cells (STC) at premier institutions like the 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, RESPOND has supported 29 new projects and 108 ongoing projects pertaining to nine Space Technology Cells. Under STCs, 25 projects have been successfully completed during the year.

Details are given in the table below:

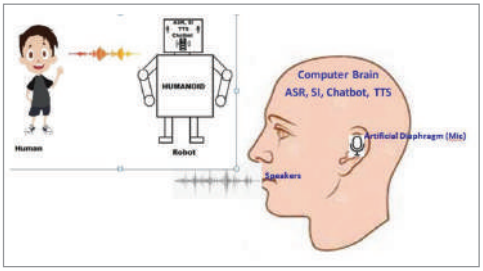
Sl. No	Name of the STC/JRP	No. of Projects		
		New	Ongoing	Completed
1.	IISc Bengaluru	14	23	15
2.	IIT Bombay	5	21	1
3.	IIT Kanpur	0	30	0
4	IIT Madras	2	21	9
5.	IIT Roorkee	8	13	0
	Total	**29**	108	25

Projects at Regional Academic Centre for Space (RAC-S): Under the Regional Academic Centre for Space programme a total of 25 projects have been supported during the year. This includes MNIT Jaipur (4), Gauhati University, Guwahati (3), and NITK Surathkal (6); NIT Kurukshetra (2); IIT, BHU (10). The projects are reviewed by domain experts in ISRO and later by Joint Policy Management Committees consisting of experts from ISRO and the academia.

6.3 Highlights of Some of the completed RESPOND Projects

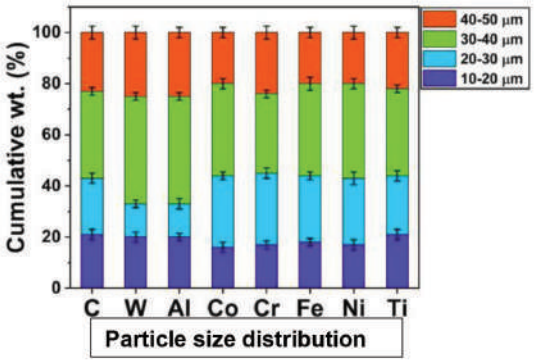
- **Speech Technologies for Humanoid**

  Under this project, the researchers successfully created Automatic Speech



Recognition (ASR) system for Hindi and English. Further, the development of a Speaker Identification System; Development of a Text-To-Speech (TTS) system for Hindi and English with male and female voices, Development of a Chatbot for Space Domain for English and Hindi, and Integration Framework on PC and Jetson Board were also taken up under this project. The developed speech technologies are useful for communication with Humanoid planned in unmanned flights of the Gaganyaan Programme.

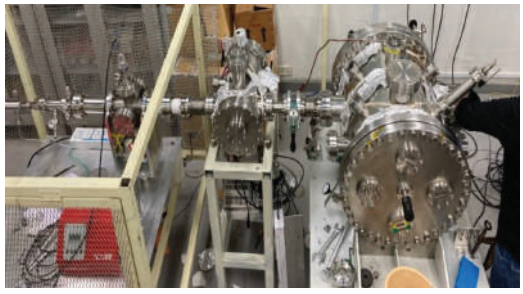
- **Development of High Entropy alloy wear resistance coating**



Under this project, AlCoCrFeNiTi and $FeCoCrNiW_{0.3}$ + 5 at % C two HEAs coating was developed using APS at stellite and inconal substrate. The outcome of this work is planned to be implemented as a replacement for chromium oxide coating in the rotating components of VIKAS engine, Cryo engine, and semi-cryo engines. The present study also demonstrated the wear resistance characteristics of the high entropy alloys developed.

- **Ion Source Facility for Calibration of Ion Mass and Energy Analyzers for Space Missions**

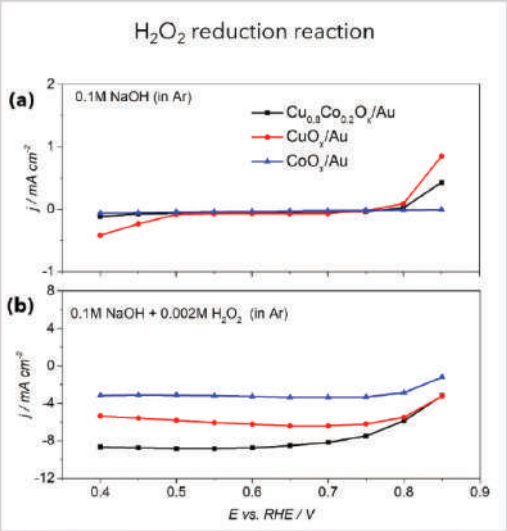
The aim of the project was to establish a facility for producing low-energy ion beams for testing charge particle detection payloads for space missions. This project is very important in light of Aditya-L1 missions, which will be flying a charged particle spectrometer (ASPEX) for the first time on an ISRO mission. The setup has been established at PRL, Ahmedabad, where the ASPEX payload for Aditya-L1 is being developed. Under this project, an ion gun facility was developed and is being very effectively used in the calibration of the SWIS subsystem of the ASPEX payload.



2.7 Capacity Building

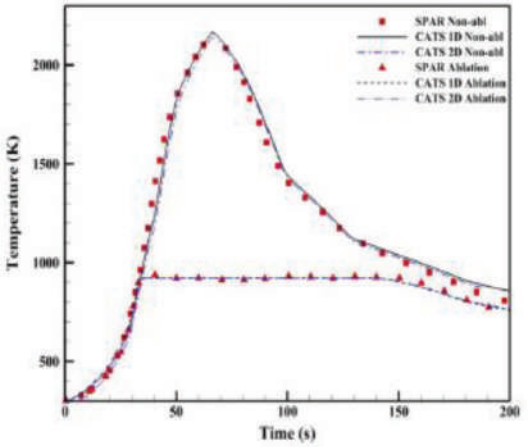
- **Oxygen reduction reaction catalyst development for fuel cells using in situ Spectroscopy**

  The project aimed at the development of new catalysts for oxygen reduction. Electrochemical characterisation, which includes the activity and selectivity of the catalyst, was carried out using the ring disc electrode method. Under this project, a new thin film catalyst for ORR has been successfully developed.



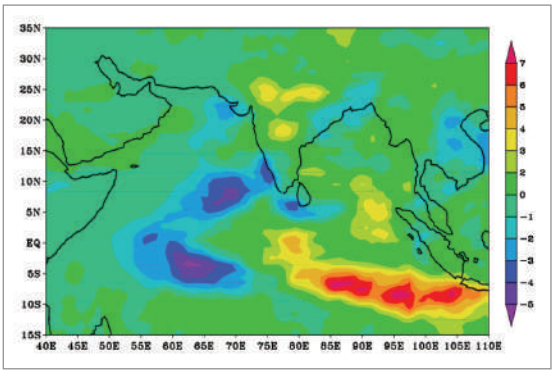
- **Numerical study of flow thermal response of a high-speed vehicle with ablative /non-ablative thermal protection system.**

  Under this project, a new thermal code is developed by combining the flow server with the thermal response code. A complete in-house 2D flow thermal code is developed to obtain the thermal response of an ablative material during the reentry of a hypersonic vehicle at high altitudes. The flow solver and material thermal response solvers have been individually validated against the available data.



Comparison of temperature obtained from thermal response solver, SPAR, of NASA with or thermal response solver with and without ablation

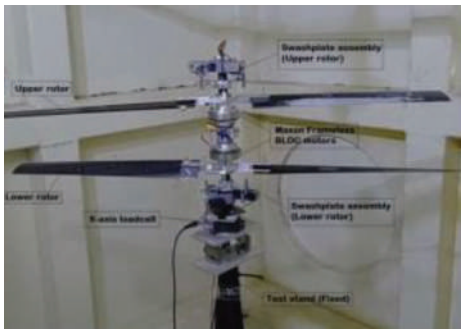
- **Radiative Impact of Clouds: Assessment of the Intraseasonal and Interannual variability during Indian Summer Monsoon Season** Under this project, the mechanisms responsible for the deficit rainfall over southwest



peninsular India during the 2016 monsoon season have been investigated. It was established that the large-scale variation in circulation pattern due to the strong, negative Indian Ocean dipole phenomenon is the reason for the deficit rainfall.

- **Development of Rotocraft UAV for Operation in Martian Atmosphere**

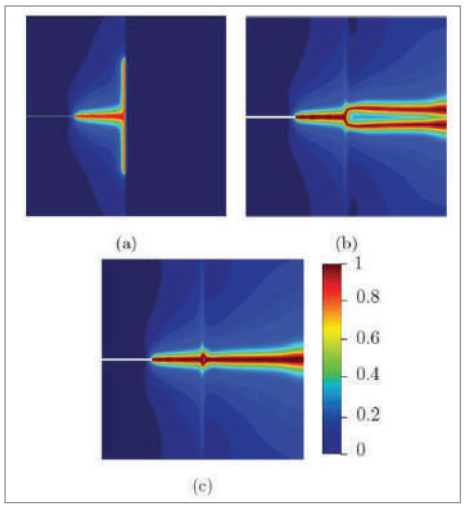
Under this project, a prototype was designed and built with fabricated as well as off-the-shelf components. Ground test prototype (GTP)) of a coaxial helicopter was also built for testing in low-density chamber. A generic controller for rotorcraft UAVs was successfully utilised for autonomous control of single-rotor helicopter UAVs and multi-rotorcraft aircraft. The project has got linkage to the Mars exploration interplanetary programme. The prototype developed is being used for testing the control algorithm. The BEMT model is being used for designing the helicopter for providing the lift.



Ground proto model on test stand

- **Computational modelling and analysis of damage in high-strength composite structures by novel non-local approach**

Under this project, a software was successfully developed for nonlocal nonlinear finite element analysis of composite plates. The proposed formulation includes geometric nonlinearity and the effect of size on constitutive behaviour. The software is capable of nonlocal nonlinear damage modeling for predicting damage in composite plates.

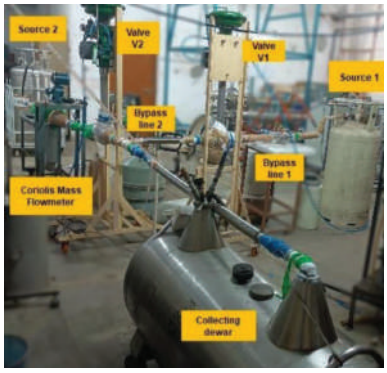


NMC syntheisedby Spray pyrrolysis and FESEM images of NMC-811

- **Theoretical and experimental studies on flow characteristics during the source switch over for feeding propellants in the liquid rocket engine test facilities.**

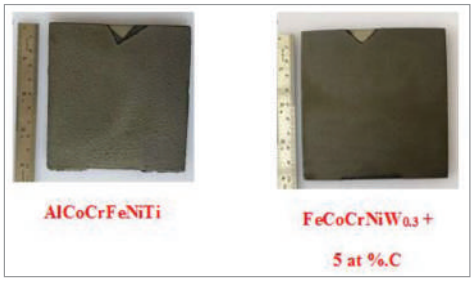
Under this project, numerical analysis was carried out for the test facility (ICET & SIET), including pipe-lines, valves etc., through detailed process simulation.

2.7 Capacity Building



Validation of numerical approaches was done through sub-scale experiments which were established at IIT, Kharagpur. This project successfully addressed the critical operation of the Source switch from the startup tank to the run tank during the regime of engine operation in liquid rocket engine testing. Subsequently, large-scale test facility problems are solved numerically to derive the optimal control strategy for source change over the operation in ICET & SIET facilities. Control logic for changeover operation is delivered for implementation.

- **Development of High Entropy Alloy Wear Resistance Coating**



Under this project, High entropy Alloy wears resistance (HEA) coatings of AlCoCrFeNiTi and $FeCoCrNiW_{0.3}$ + 5 at %.C was developed using the Atmospheric Plasma Spray process. The surface morphology, mechanical properties, crystalline properties, and phase transformation properties of the coating were investigated both as coated and after laser processing. Promising results were obtained, and the developed HEAs exhibited superior properties than the conventional Cr_2O_3 coating used in the rotating components of Vikas, Cryogenic, and Semi-cryogenic engines.

7. ISRO ACADEMIA Day – 2022

ISRO has always looked for greater participation and contributions from academia in a focused manner, for carrying out R&D Projects of relevance to the ISRO Programme.

ISRO Academia Day-2022 was organized through virtual mode on March 15, 2022. **ISRO Academia Day-2022** aimed at providing a common platform for Academia as well as the scientific community of ISRO to share their knowledge, and experience and create awareness about the opportunities available in ISRO for the promotion of Space Science & Technology, Education, and Research. **RESPOND Basket 2022** was also released during the event.

8. I-Grasp Online Portal:

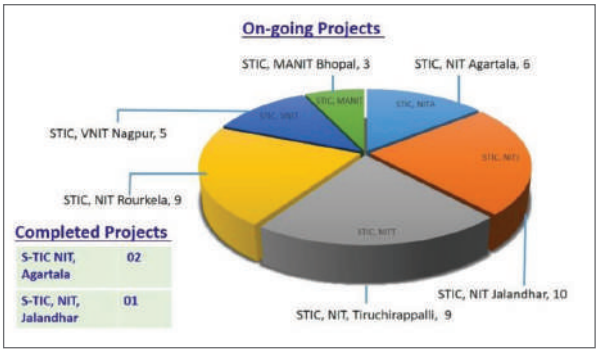
ISRO has also launched "**I-GRASP**" online portal (ISRO **GR**ant in **A**id for **S**pace **R**esearch **P**rogrammes). The portal invites proposals from academia online and processes them online. The PIs from the academic institutions, based on their area of interest and expertise, select and submit the research proposals through this portal. Further, the entire process of evaluation and approval is also carried out through this portal. The portal supports the submission of proposals under RESPOND/Space Technology Cells (STC)/ Space Technology Incubation Centres (S-TIC) and Other Grant in Aid programmes.

During the current year, against 195 research problems projected under RESPOND Basket, around 1120 proposals have been received online through the I-Grasp Portal.

9. Space Technology Incubation Centres

Space Technology Incubation Centre (S-TIC) is an initiative to attract and nurture young academia with innovative ideas/research aptitude for carrying out research, motivating and encouraging them to initiate startups and businesses in the field of space technology & applications and developing theAcademia–Industry ecosystem for Space Technology.

At present, six S-TIC are functioning, one each, at six regions of the country viz. at NIT Agartala (North-Eastern zone), NIT Jalandhar (North zone), NIT Tiruchirappalli (South zone), MANIT, Bhopal (Central zone), VNIT, Nagpur (Western zone) and NIT Rourkela (Eastern zone). 3 Projects have been completed at these S-TICs, and 42 projects are in progress.



During2022, S-TIC have created a remarkable impact by providing hands-on expertise to more than 350 students of various engineering/science disciplines for state-of-the-art technical incubation and product development activities related to Space Science and Technology.

2.8 Technical Facility / Infrastructure

Creation of new facilities and establishment of infrastructure across the ISRO centres in line with programmatic requirements, and long-term goals, Atmanirbhar Bharat and Space-sector reforms assumes greater significance.

Facilities or infrastructure established at different centres is detailed here.

VSSC

Trisonic Wind Tunnel

Trisonic Wind Tunnel

The Trisonic Wind Tunnel is a system to aid the aerodynamic design of rockets and re-entry spacecraft by characterizing scaled models by evaluating forces, moments, load distribution, unsteady pressures, acoustic levels etc. The tunnel can simulate flight conditions from 0.2 times the speed of sound (68 m/s) to 4 times the speed of sound (1360 m/s). The Model Cart system, which supports the model, houses the model incidence mechanism, supports transonic Mach number control, and also has interfaces for data acquisition from the model, is established. The first trial blowdown of the integrated system was carried out on December 08, 2022.

Next generation high power density fuel cell stack upto 20 kW

Inauguration of LIFE complex

A facility named "Laboratory for Integrated Fuel Cell Engineering (LIFE)" was established as part of the developing high high-power density fuel cell stack. LIFE involves facilities for integrated design, development, processing, assembly, integration, and testing of PEM fuel cell stacks up to 20 kW. Major facilities include ultrasonic slurry mixing and spray coating machines, precision hydraulic hot press, electrochemical impedance analyser, air oven, vacuum oven, robotic fluid dispensing station, electro-mechanical compression system, furnace, fuel cell test station along with auxiliary systems such as chillers and COMSOL multi physics work station.

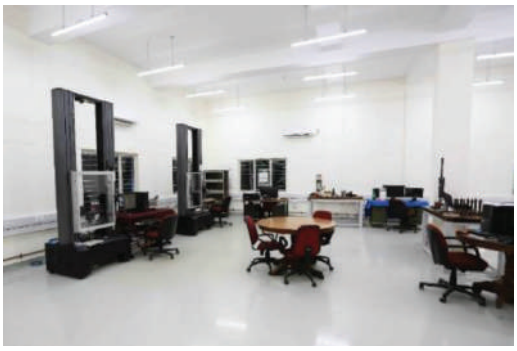
GANGA

GANGA facility is meant for the preparation of launch vehicle battery and satellite separation systems. The facility contains automated battery cycling systems, silver zinc electrolyte filling & soaking facilities, battery storage facilities, and assembly and harnessing facilities. The facility was declared open by Chairman, ISRO/Secretary, DOS on August 12, 2022.


Battery Preparation Facility

Mechanisms and Robotics Lab

A state-of-the-art robotics lab for the design and development of robotic arm and docking mechanisms was established on August 25, 2022. It caters to qualification and acceptance testing of staging system components, bought-out items, as well as re-verification of Functionally Critical Dimension (FCD) of flight components.



Mechanisms and Robotics Lab

LPSC

Integrated Cryo Engine Manufacturing (ICMF)

- ICMF is established for realisation of cryogenic and semi Cryogenic Engines. This will be additional facility for engine realisation. The facility was inaugurated by the Honorable President of India, Smt. Draupadi Murmu on September 27, 2022.

2.8 Technical Facility / Infrastructure

Inauguration of ICMF by Honorable President of India

ISTRAC

System for Safe & Sustainable Space Operation and Management (IS⁴OM)

System for Safe & Sustainable Space Operation and Management (IS⁴OM) was dedicated to the nation by Hon'ble Minister of State (Space) Dr. Jitendra Singh on July 11, 2022.

Safe & Sustainable Operations Management is responsible for safeguarding ISRO's operational space assets against space environmental threats and for ensuring that ISRO's outer space activities are conducted in a safe and sustainable manner.

To cater to the long-term sustainability (LTS) requirements, focused activities are undertaken to enhance capabilities for monitoring and analysis of the space environment, including space debris. The prime activities undertaken are NETRA (NEtwork for space object TRacking and Analysis) project management for the establishment of space-object observational facilities and a control center for all SSA (Space Situational Awareness) related activities.

These activities include observational data processing and space object cataloging, keeping continual vigil on the close approaches of other objects to ISRO's operational assets, and performing collision avoidance maneuvers whenever needed, along with the necessary coordination and data exchange with

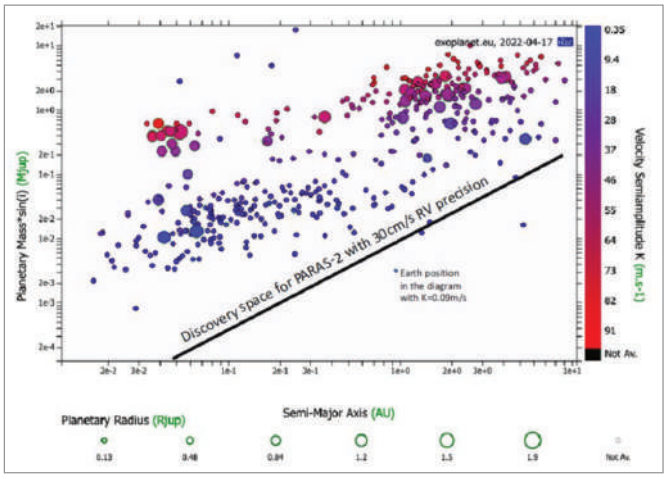
Inauguration of IS⁴OM Control Center

external entities to resolve potentially risky conjunctions. Other activities include adopting measures to improve compliance with internationally accepted space debris mitigation guidelines, regular atmospheric re-entry risk analysis, aerothermal break-up, and fragmentation analysis, and modeling of space debris population. Efforts are underway for Near-Earth Object (NEO) observations, tracking, and monitoring towards planetary defense. SSOM participates in the global efforts on LTS of outer space activities through collaboration with other space entities and also contributes to raising awareness among all concerned private/academic players to promote responsible, safe, and sustainable space operations.

PRL

2.5 m Telescope

The PRL 2.5m Telescope was recently installed at the PRL Astronomical Observatory at Gurushikar, Mt. Abu, Rajasthan. It is one of the country's most technologically advanced state-of-the-art telescopes with an Active Optics System consisting of 42 actuators behind the Primary mirror and 14 lateral actuators to maintain a near-perfect concave hyperbolic shape of the mirror with the surface figure of rms of 25 nm. This helps to produce very high quality seeing limited star images down to sub-arcsec star FWHM (full-width half maximum). The telescope also has a tip/tilt system for 1st order atmospheric in one of its side ports for precise star images at the focal plane. Primary Science targets for the telescope are a) exoplanets sciences, and b) transient phenomena like GRBs, novae and super-novae which require high cadence dedicated telescope times and Target of Opportunity Observations (TOO). The plots below provide the initial outcomes.



Discovery space of PARAS-2 at sub-1m/s (30 to 50cm/s) detection limits

The image of spiral galaxy NGC295 taken by FOC in the SDSS v-band

2.9

Quality Management, Occupational Health & Safety

1. Introduction

The year 2022-23 registered the launch of India's first privately developed launch vehicle from ISRO's premises and the setting up of the first privately developed launch pad and mission control centre at Satish Dhawan Space Centre (SDSC SHAR/ ISRO), Sriharikota. The results of the space reforms have started becoming visible, and many more private missions are lined up this year. While India has set her eyes on significantly enhancing her share of the global space business, the Department of Space/ ISRO has kept strict vigil on the quality and safety aspects towards enabling the smooth achievement of these national goals. The quality and safety teams across ISRO Centres and Units continued to critically examine the various activities of ISRO missions and also continued to hand-hold the private players towards ensuring mission success.

A dedicated Directorate of Safety, Reliability, and Quality (DSRQ) at ISRO Headquarters closely interacts with the various safety, quality and occupational health-related teams spread across the centres and units of ISRO/DOS. The Directorate of Safety, Reliability, and Quality (DSRQ) strives towards enabling greater synergy within the safety and quality teams across ISRO. DSRQ also interfaces with the recently established Indian National Space Promotion and Authorisation Centre (IN-SPACe) towards various critical aspects of Safety and Quality. A few significant contributions of the Safety, Quality, and Reliability teams of ISRO/DOS are highlighted below.

2. Safety, Reliability and Quality assessment of ISRO Missions

Operational Missions

Safety, Reliability, and Quality teams contributed significantly towards the quality control, testing, quality assurance, and reliability, safety assessment activities for two NSIL missions, namely **PSLV C53/DS-EO & LVM3 M2/One-Web India-1** and an ISRO operational mission, **PSLV C54/EOS-06**. All these missions also had the involvement of DSRQ in major review fora as the independent voice of safety and quality.

Developmental Missions

With a greater focus on developmental missions, the safety and quality teams worked towards the certification, quality assurance, and safety aspects of novel technologies for the Re-usable Launch Vehicle - Landing Experiment (**RLV-LEX**) and the first developmental flight of a Small Satellite Launch Vehicle (**SSLV D1**). Several important lessons were learned from these developmental missions, and further enhancement of the quality and safety practices is under implementation for future missions. DSRQ also carried out an independent assessment of both these

missions towards confidence building and identification of possible improvements in future missions.

All the above missions were accomplished without any major safety-related issues and the meticulous contributions of the safety and quality teams continue for the upcoming missions.

3. Safety, Reliability and Quality Assessment of Vikram-S rocket of M/s Skyroot Aerospace

DSRQ carried out an Independent Assessment of India's First privately developed launch vehicle – Vikram-S Rocket (Mission Prarambh) of M/S Skyroot Aerospace, and provided specific confidence building with respect to Range safety and the Safety of the Launch Pad by making critical assessment towards clearing the mission without Flight Termination System. DSRQ is also a key member of the high-level committee for review of the safety and quality aspects of this and future launch vehicle missions of Non-governmental Private Entities (NGPEs).

4. Security of space assets and capabilities

Security of all the space assets in-orbit and the ground assets and capabilities is given utmost importance by DOS and is regarded as an element of national security. A top-level committee is working dedicatedly toward identification of the various threats to space assets and their various mitigation strategies. Key technologies and critical infrastructure to be developed for further enhancing the security of space assets and capabilities are being taken up in a fast-track mode. DSRQ spearheads this activity in close coordination with the various experts of ISRO, and the report of the first phase activities has been released.

5. Interactions with Ministries and other Departments of the Government of India

DSRQ served as the nodal agency from ISRO for the following three major activities

a. Review of Crisis Management Plan of Department of Space by Secretary, Security (Cabinet Secretariat), Government of India

Review of preparedness of the Department of Space with respect to various crisis scenarios, including cyberattacks, natural disasters, and also with respect to disabling of satellites, was taken up towards giving confidence on the same. Two documents,

namely, the Crisis Management Plan of DOS and Contingency Plan with respect to Disabling of Satellites, were reviewed and released to all DOS Centres/ Units for Implementation. The systems and processes in place at DOS for the management of all possible crisis scenarios are found to be in order, and key steps for further enhancement have been identified.

b. Central Government Exemption for ISRO from the operation of all the provisions of the Explosives Rules, 2008 for manufacturing, storage, use, and transportation of solid propellants falling under UN Class 1 (Explosives) through Gazette Notification by DPIIT November 11, 2022

DSRQ, ISRO HQ has been closely coordinating with DPIIT (Department for Promotion of Industry and Internal Trade) of the Ministry of Commerce & Industry to streamline the explosives-related activities in our organization. After several rounds of deliberations with the officials of DPIIT & CCoE (Chief Controller of Explosives) and a facility visit to SDSC SHAR, the Ministry of Industry & Commerce (GoI) has approved the exemption to ISRO. This exempts ISRO/DOS from the operation of all the provisions of the Explosives Rules, 2008, for manufacturing, storage, use, and transportation of solid propellants falling under UN Class 1 (Explosives). The Board of Occupational Health and Safety has worked out an elaborate mechanism to ensure that strict control is maintained with respect to all the safety measures in this area and also laid out the strategy for the meticulous implementation of the guidelines of STEC (Storage and Transportation of Explosives Committee) and the biennial safety audit of the solid propellant manufacturing facilities as mentioned in the gazette notification.

c. Clearance for Offshore Wind Development project of the National Institute of Wind Energy (NIWE) at the Gulf of Mannar and Gulf of Khambat-

Enabled in the issuance of Stage-I Clearance to National Institute of Wind Energy (NIWE), Ministry of New & Renewable Energy for the Offshore wind farm project near the Gulf of Khambat, off Gujarat Coast and Gulf of Mannar, off Tamil Nadu coast after several rounds of discussion with Launch Vehicle Mission Team and Range Safety Team of ISRO and Joint Secretary, Ministry of New and Renewable Energy (MNRE) & Director, NIWE. This gained special significance in light of the upcoming spaceport at Kulasekharpatinam, Tamil Nadu, near the gulf of Mannar.

6. Safety and Quality Procedure – Enabling Health Sector (Health QUEST Program)

The best quality practices shared with the Indian medical fraternity in the form of Health-Quest during the year 2016 were implemented on a trial basis in a major hospitals in Bengaluru and Chennai. Based on the benefits experienced, the study was further extended to 11 more identified hospitals across India, which has yielded positive results in reducing mortality rates in Emergency care and Critical care departments. Amongst the many benefits derived from this joint effort, a few of the major outcomes are the Re-Designing of the Emergency-care Department, considering the Space, Manpower, Patient flow and the Training needs for standardization, Identifying the necessity of establishing Emergency Department Quality teams, Employing useful quality tools in the department.

In order to improve the benefits further and fine-tune the implementation strategy, the outcomes of the study were deliberated at ISRO Headquarters on May 26, 2022, with the participation of members from the Indian medical fraternity and ISRO experts. During the event, ISRO also exchanged its expertise in developing medical emergency systems and the methods being followed to handle the interplay among Man, Machine and Environment in its Human Space flight program.

Participants at the Health-QUEST event organised by DSRQ at ISRO HQ

7. Safety and Quality Culture

It is the culture of meticulous care and attention to finer details that translates into success for complex space missions. ISRO/DOS puts enormous energies into sustaining this culture of care through all its teams, specifically the safety and quality teams of ISRO. Various awareness initiatives for new joiners and refresher programs for the existing staff are conducted on a periodic basis, including events like Safety

mock drills, Quality Day, Safety Day, Fire service day, world environment day, various competitions, and training programs/conferences/seminars.

8. Major achievements of Safety and Quality teams – Developmental activities

ISRO/DOS is making rapid progress on the upcoming Gaganyaan mission, and several significant milestones with respect to the qualification, testing and human-rating certification of the various systems of the launch vehicle, crew escape system, crew module, service module, launch base, test vehicle etc. have been accomplished with the close involvement of the safety and quality teams. Specifically, the testing of the human-rated S200 motor, solid motors for the Crew escape system, margin demonstration tests on the Vikas engine, integrated main parachute airdrop test, and crew module- system demonstration model tests were successfully completed with the close involvement of Safety and Quality teams.

The Human Rating Certification mechanism is implemented, and the system is in place. The software to automate the certification process is implemented and is operational through web pages of all centres. All centres are equipped to carry out Probabilistic Risk Assessment (PRA) studies, and studies are in progress for India's human spaceflight mission.

Initiatives for continual improvement in the quality of space systems and also towards further enhancing the safety of the various activities are progressing steadily in all four major areas of ISRO, namely Space Applications, Spacecraft systems, Launch Vehicle Systems and ground systems. High-pressure leak checks of the gas bottle and propellant tanks for the Chandrayaan-3 mission, qualification test plan for Carbon Nano Tube based High Absorber Coating for Star Sensor baffles, process qualification of Ceramic Column Grid Array (CCGA), process review for the realisation of System on Chip (SoC) for On-board computer for future nanosatellites, risk assessment of orbital debris impact on the NASA-ISRO Synthetic Aperture Radar (NISAR) spacecraft and establishment of an Independent End to End Closed Simulations Test Facility for Chandrayaan-3 project are some of the other key accomplishments of the quality teams.

As a part of software quality assurance, quality teams developed algorithms to estimate cloud cover percentage for images towards analyzing the system-level products. Development of an online web-based Instrument Calibration Management and alerting System (ICMAS), Establishment of a microwave calibration site for NISAR

calibration, and development of a radiometric calibration site in the wavelength range of 350 nm – 2500 nm, supported by external agencies such as USGS (United States Geological Survey) in carrying out radiometric characterisation for Landsat-9 OLI (Operational Land Imager) mission during its commissioning phase are some of the key contributions.

Safety review of radiation sources for various spacecraft was also completed and Safety committees at various ISRO/DOS Centres reviewed and cleared locations for the construction and commissioning of new facilities.

In summary, the year has been a combination of successes and lessons, and the safety and quality teams are forging ahead with their eyes firmly on future missions. The renewed focus of DOS towards R&D opens up new vistas for safety and quality professionals in the days to come.

2.10 International Cooperation

Indian Space Research Organisation (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 more diverse, in tune with ISRO's enhanced capabilities.

Till date, ISRO/DOS and India have signed space cooperative documents with space agencies of 61 countries (Afghanistan, Algeria, Argentina, Armenia, Australia, Bahrain, Bangladesh, Bhutan, Bolivia, Brazil, Brunei Darussalam, Bulgaria, Canada, Chile, China, Colombia, Egypt, Finland, France, Germany, Hungary, Indonesia, Israel, Italy, Japan, Kazakhstan, Kuwait, Luxembourg, Maldives, Mauritius, Mexico, Mongolia, Morocco, Myanmar, Nepal, Nigeria, Norway, Peru, Portugal, Republic of Korea, Russia, Sao-Tome & Principe, Saudi Arabia, Singapore, South Africa, Spain, Sri Lanka, Sultanate of Oman, Sweden, Syria, Tajikistan, Thailand, The Netherlands, Tunisia, Ukraine, United Arab Emirates, United Kingdom, United States of America, Uzbekistan, Venezuela and Viet Nam) 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, 12 cooperative documents with foreign entities were signed during this period. They are: (1) Memorandum of Understanding (MoU) between the Indian Space Research Organisation and the Mohammed Bin Rashid Space Centre Regarding Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes; (2) Implementing Arrangement (IA) between Indian Space Research Organisation and Mohammed Bin Rashid Space Centre on cooperation in aerosol and greenhouse monitoring satellite missions; (3) IA between Indian Space Research Organisation and Australian Space Agency relating to cooperation on Establishing and Operating Transportable Telemetry Terminals in The Cocos Keeling Islands, Australia for the Gaganyaan Human Space Flight Mission; (4) MoU between the Government of the Republic of India and the Government of the Grand Duchy of Luxembourg on cooperation in the exploration and use of outer space for peaceful purposes; (5) Agreement between the Indian Space Research Organisation and the National Aeronautics and Space Administration of the United States of America for deep space network DSN for ISRO's Chandrayaan-3 lunar lander and Chandrayaan-2 lunar orbiter missions; (6) IA between the Indian

Space Research Organisation of the Republic of India and the National Aeronautics and Space Administration of the United States of America for cooperation on the Chandrayaan-3 mission; (7) MoU between the Department of Defense of the United States of America and the Department of Space of the Government of the Republic of India for cooperation in safety of spaceflight and the provision of space situational awareness services and information; (8) Charter on the establishment of the Space for Climate Observatory (SCO); (9) Specific Cooperation Agreement between the Indian Space Research Organisation, Department of Space of the Republic of India and the Mexican Space Agency of the United Mexican States on crop monitoring drought assessment and capacity building; (10) Letter of Intent between the Indian Space Research Organisation and the Centre National Detudes Spatiales, France; (11) MoU between Physical Research Laboratory and National University of Singapore for collaboration in quantum science & technologies and allied applications; and (12) Agreement between Indian Space Research Organisation and Physikalisch-Technische Bundesantalt on collaboration for installing & reception of data from NavIC receiver.

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 to JPL, USA for conducting various joint S-band & L-band payload integration tests. Many technical review meetings have been conducted, including that of NISAR Joint Steering Group, NISAR Remote Access Working Group, and NISAR Senior Management meetings. Under the IA signed with NASA, NASA's LRA instrument got integrated into the Chandrayaan-3 lander. ISRO-NASA Joint Working Group on Heliophysics, Planetary Science and Human Spaceflight Programme had meetings to explore collaboration opportunities in 2022. As part of ISRO-NOAA cooperation and CGMS initiative, ISRO started receiving commercial radio occultation data of 6,000 profiles/day. ISRO – NOAA cooperation in Heliophysics had many technical meetings for joint Cal/Val and data exchange possibilities. Under the ISRO-NASA Professional exchange programme (PESEP) two officials (USGS & NOAA) visited ISRO centers (SAC, NRSC, NARL & IIRS) and had collaboration discussions.

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, and returned to India. On the supply of components and systems required for the Gaganyaan mission, good progress has been made with respect to the supply of viewport, space suits, and crew seats. Wind Tunnel testing of the

2.10 International Cooperation

Gaganyaan Crew Module and Crew Escape System is progressing at the Glavkosmos facility with three models supplied by ISRO. The discussion has also progressed well with respect to the establishment of the NavIC reference station in Russia and the GLONASS reference station in India. In connection with the enhanced cooperation, an India – Russia Technology Protection Agreement which was signed in December 2021, is currently under a statutory ratification process. As a new initiative under India-Russia space cooperation, ISRO and the Russian Academy of Sciences (RAS) have started exploring cooperation in space science 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 in French Guyana is also progressing. Under the ISRO-CNES agreement on HSP, Indian flight surgeons and ground support technicians had undergone specific training at CNES, Toulouse, France, and at Astronaut Training Centre, Cologne, Germany. ISRO team also participated in the debriefing session of ESA astronaut who returned from ISS.

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. The validity of IA for Agromet collaboration with JAXA was extended up to November 2025.

ISRO and European Space Agency (ESA) have enhanced their cooperation from earth observation and space exploration domains to other areas. Cooperative documents were signed for Network and Operations Cross-support and also for ESA's ground station support for ISRO's Chandrayaan-3 and Aditya-L1 missions. Both sides have agreed to conduct calibration testing of the NavIC - Galileo timing receiver at the ESA facility to estimate the time offset.

Chairman ISRO/Secretary DOS participated in the 1st Meeting of the Joint Committee on Space Cooperation under the Agreement on Cooperation on Remote Sensing Satellite Constellation. ISRO virtually participated in the 'BRICS Remote Sensing Satellite Constellation Application Forum' organized by CNSA, China.

The 3rd batch of the UNNATI (nanosatellite training) programme was successfully

organised at ISRO from October 15 to December 15, 2022. A total of 31 officials from 19 countries (Argentina, Armenia, Bhutan, Chile, Dominican Republic, Ecuador, El Salvador, Ethiopia, Fiji, Mexico, Nicaragua, Panama, Papua New Guinea, Philippines, Singapore, Slovakia, Sudan, UAE, and Uzbekistan) participated and provided excellent feedback.

As announced during the visit of the Honorable Prime Minister of India to Bhutan in August 2019, India and Bhutan worked towards the joint realisation of a small satellite. With the signing of IA for the joint realisation of the satellite, Bhutan engineers underwent training in India as part of the Phase-2 training and design & validation of the secondary payload of the satellite. The India and Bhutan satellite was launched by PSLV-54 from Sriharikota.

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 the Gaganyaan mission.

Under India-ASEAN cooperation, the site survey of the allotted land for ISRO Ground station construction at Ho Chi Ming City, Vietnam, and training of ASEAN officials in space technology and applications at IIRS were carried out. ASEAN Secretariat, Jakarta has extended the ISRO-ASEAN agreement for the Ground station till 2029 and also allotted the funds for 2022-2023 Ground station activities and training of ASEAN officials at ISRO.

Chairman ISRO/Secretary DOS virtually participated and delivered a talk at the Heads of Agency session at the G20 nations 3rd edition of the Space Economy Leaders Meeting (SELM) held in Indonesia. Under India's G20 Presidency in 2023, ISRO has initiated activities towards organising the 4th edition of SELM at Bengaluru in July 2023.

ISRO delegation led by Chairman, ISRO/ Secretary, DOS participated in the 73rd International Astronautical Congress (IAC 2022) in Paris, France. Chairman, ISRO/ Secretary, DOS delivered keynote talk at the Heads of Agency plenary and had meetings with his counterparts from USA, France, Japan, ESA, and Israel in addition to the bilateral meetings with heads of other key space agencies at the sidelines of IAC 2022.

Eleven ISRO officials have become Corresponding Members, and one became a full member of the International Academy of Astronautics (IAA), Paris.

In the field of capacity building, ISRO continues to share its facilities, and expertise in the application of space science and technology by conducting short-term and long-

2.10 International Cooperation

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 59th session of the Science and Technology Sub Committee (STSC), 61st session of Legal Sub Committee (LSC) and in 65th session of UNCOPUOS. Shri Umamaheswaran. R, Director, HSFC as the Chair of the STSC Working group on Long-Term Sustainability of outer space activities (WG-LTS) chaired the formal and informal intersession meetings.

Many dignitaries, including the Mexican Minister for Foreign Affairs, Bhutanese Minister for Information and Communication, Italian Minister for Foreign Affairs, and Ambassadors of Israel, Colombia, the Dominican Republic, the Republic of Korea, Romania, Luxembourg, Netherlands, and Slovenia have visited ISRO facilities.

ISRO also actively participated in the meetings of prominent multilateral fora, including the Asia-Pacific Regional Space Agency Forum (APRSAF), the International Astronautical Federation (IAF), the International Academy of Astronautics (IAA), the 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), Space for Climate Observatory (SCO) and United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS).

2.11 Space Commerce

1. Enhanced Mandate of NSIL

"NewSpace India Limited (NSIL)" got incorporated in March 2019 as a wholly owned Government of India Undertaking/ Central Public Sector Enterprise (CPSE) under the administrative control of the Department of Space.

In June 2020, as part of Space Reforms **"Unlocking India's potential in 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.

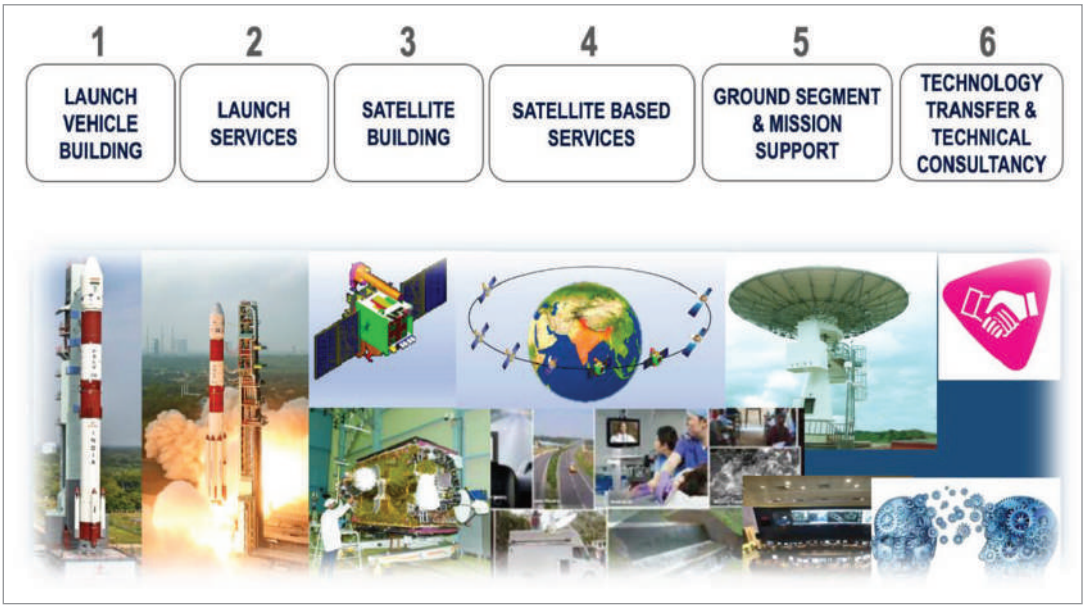
As part of Space Reforms, the Enhanced Mandate of NSIL is as indicated below:

- **Owning satellites** for Earth Observation and Communication applications and providing space-based services
- **Building satellites** and launching them as per demand
- **Providing Launch Services** for satellites belonging to a customer
- **Building launch vehicles** through Indian Industry and **launching** as per satellite customer requirement
- **Space-based Services** related to Earth Observation and Communication satellites on a commercial basis
- **Satellite building** through Indian Industry
- **Mission Support Services** to National and International Customers
- **Technology Transfer** to Indian Industry

2. Business Verticals

To cater to the business needs and the enhanced mandate of NSIL as approved by the Cabinet, it has created six business verticals as indicated next:

2.11 Space Commerce



3. Business Operations

NSIL made a good stride in all its major business operations as per the enhanced mandate. Major highlights of business accomplishments from April 1, 2022 to December 31, 2022 are as under:

3.1. Owning and operating the satellites on Demand Driven model

- **GSAT-24 communication satellite: 1st Demand Driven Mission of NSIL**
  - NSIL undertook its 1st Demand Driven Communication Satellite Mission named GSAT-24, meant to meet Direct-To-Home (DTH) service needs. NSIL got this satellite built by ISRO. The satellite was successfully launched on board Ariane-V [VA 257 flight] from Kourou, French Guiana, on June 23, 2022. GSAT-24 satellite has been positioned at its designated orbital slot, i.e., at 83° E, and presently undergoing in-orbit testing. Once the satellite is commissioned, the entire satellite capacity will be leased to its committed customer M/s Tata Play. Entire funding for this mission has been borne by NSIL.

- **Discussions with potential customers for undertaking 2nd and 3rd Demand Driven Communication Satellite Missions for NSIL:**
  - **GSAT-20:** NSIL is in discussions with potential customers for utilising the services of GSAT-20, a 4-tonne class High Throughput Satellite (HTS) for meeting Broadband connectivity needs.

3.2. End-to-End Launch Vehicle building through Indian Industry

* NSIL has been mandated for the End-to-End building of ISRO's launch vehicles through the Indian Industry.
* As part of this mandate, NSIL has signed a contract with M/s HAL [Lead Partner of M/s HAL and L&T consortia] for manufacturing five nos of PSLV. The 1st fully Indian Industry manufactured PSLV will be realised by 2024, and subsequent vehicles every six months.

3.3. Launch Services for customer satellites on-board ISRO's Launch Vehicle

* As of date, NSIL has successfully launched 48 International and 1 Indian customer satellite on board PSLV. This includes the successful completion of 2 Dedicated Customer satellite missions onboard PSLV. In addition, NSIL has in hand three more Dedicated PSLV Launch Service agreements for launching international customer satellites during 2023 and 2024.
* NSIL successfully accomplished its 2nd dedicated commercial launch mission by launching the DS-EO satellite along with two co-passenger satellites from Singapore on June 30, 2022 onboard PSLV-C53.
* NSIL has launched 36 OneWeb LEO Broadband Communication Satellites for M/s Network Access Associates Limited (M/s OneWeb), United Kingdom onboard LVM3 on October 23, 2022. This was a historic milestone for NSIL as with this GSLV- MkIII (LVM3) has made its entry into Global commercial launch service market. NSIL will be launching another set of 36 OneWeb LEO Broadband Communication Satellites onboard LVM3 during Feb 2023.
* NSIL has launched 7 Co-passenger Customer Satellites – Thybolt-1 and Thybolt-2 of Dhruva Space, India; Anand Satellite of Pixxel Inc., USA; and 4 Satellites of Astrocast, Switzerland, under the commercial arrangement – onboard PSLV-C54 during November 2022.

3.4. Satellite Building

* NSIL has submitted Techno-Commercial Proposals to domestic and international customers towards viz. (a) building Communication satellites; (b) building Earth Observation Satellites; (c) providing Satellite Bus Platforms; and (d) establishment of Ground Segment.

* NSIL is in the process of building a Spacecraft Bus for an Indian Customer for launch onboard PSLV during Q3 of 2023.

3.5. Satcom Services

* NSIL, as part of SATCOM Services, is provisioning transponders in C, Ku and Ext. C band onboard INSAT/ GSAT satellites for various applications like DTH, VSAT, TV, and DSNG. In addition, NSIL is also provisioning transponder capacity from Foreign satellites to Indian users on a back-to-back arrangement basis.
* During July 2022, Union Cabinet, Govt. of India (GoI) approved the transfer of 10 in-orbit communication satellites viz. GSAT-8, GSAT-10, GSAT-12R, GSAT-14, GSAT-15, GSAT-16, GSAT-17, GSAT-18, GSAT-30 and GSAT-31 from GoI to NSIL with effect from 01st April 2021. With this transfer, NSIL owns these 10 satellites and provides various services like DTH, VSAT, TV, DSNG etc., to the customers from Government, Private and public sectors under 150+ Agreements/ MOUs.
* NSIL is also commercializing HTS capacity on-board GSAT-11, GSAT-19, and GSAT-29 satellites to Government/ Private/ Public Sector users.

3.6. Mission Support

* To date, NSIL has provided Six (6) Launch Vehicle Tracking Supports and Two (2) Launch and Early Orbit Phase (LEOP) supports to Indian and International Customers as part of Mission support services.
* NSIL provided Launch Vehicle Tacking Support to an International customer in December 2022.
* NSIL continues to provide TTC support for Amazonia-1 Mission for the second year.
* NSIL has signed four contracts for providing Deep Space Mission Support and Mission Support Service Contracts for International and Indian Customers during 2023.

3.7. Technology Transfer & Spin-off

* To date, NSIL has signed 25 Technology Transfer Agreements for transferring ISRO-developed Technologies to Industry.

* During the year, NSIL has signed 6 Technology Transfer Agreements.
* In the area of Technology Transfer, the most significant achievement for NSIL is the transfer of IMS-1 satellite bus technology to the Indian industry.
* About 900 Nos. of ASICs have been supplied to Indian Industry for locomotive applications, with technical support from Semi-conductor Laboratory (SCL).

2.12 IN-SPACe

Space Sector Reforms & IN-SPACe

Space sector reforms were announced by the Government of India in June 2020 and enabled the participation of the Indian private sector in the entire gamut of space activities. To facilitate private sector participation, the Government created the Indian National Space Promotion and Authorization Centre (IN-SPACe), as a single-window, independent, nodal agency which functions as an autonomous agency in the Department of Space (DOS). Established as a single window agency for all space sector activities of private entities, IN-SPACe plays an important role in boosting the private space sector economy in India.

IN-SPACe is responsible to promote, enable, authorize and supervise various space activities of the NGEs that include, among others, the building of launch vehicles & satellites and providing space-based services; sharing of space infrastructure and premises under the control of DOS/ISRO; and establishment of new space infrastructure and facilities. Three Directorates viz., Program Management and Authorization Directorate (PMAD), Technical Directorate (TD) and Promotion Directorate (PD) are carrying out the functions of IN-SPACe.

Major Achievements:

a) IN-SPACe has put in place the Standard Operating Procedures (SOPs) for processing the proposals from NGEs seeking ISRO Support, Authorization and Transfer of Technologies and registration of satellites as Indian Space Objects.

b) IN-SPACe Digital Platform (IDP) has been created and operationalized. All the proposals from NGEs are being received online in this portal. Registration of NGEs, a compilation of the Indian Space Industry Capability Matrix, etc., are being carried out on this digital platform.

c) A total of 202 applications have been received so far from 163 NGEs. The nature of requests includes authorization, handholding, facility support and consultancy & Technology Transfer. 26 MoUs have been signed with the NGEs for providing necessary support from IN-SPACe and ISRO Centres/Units. So far, a total of 11 Joint Project Implementation Plan (JPIP) documents have been signed between NGEs, IN-SPACe and ISRO work centre for the work packages to be carried out by ISRO for NGEs. Out of these 11 JPIPs, work on 8 JPIPs has been completed.

d) The following Five authorizations have been issued by IN-SPACe for the deployment and operationalization of satellites, hosted payloads and launch of sub-orbital launch vehicles.

   i. ROBI Payload developed by M/s.Digantara Research and Technologies Pvt Ltd., Bengaluru launched onboard the PSLV Orbital Experimental Module (POEM-1) of PSLV-C53 Mission as a hosted payload on June 30, 2022.

ii. Dhruva Space Satellite Orbital Deployer-1U (DSOD-1U) developed by M/s.Dhruva Space Pvt Ltd., Hyderabad launched onboard PSLV Orbital Experimental Module (POEM-1) of PSLV-C53 Mission as a hosted payload on June 30, 2022.
iii. Technology demonstration satellite 'AzaadiSAT' by M/s.Space Kidz India, Chennai launched onboard SSLV-D1 on August 07, 2022. However, the satellite could not be placed in orbit.
iv. "Thybolt-1" and "Thybolt-2" satellites realised by M/s. Dhruva Space Pvt Ltd launched onboard PSLV-C54 on November 26, 2022.
v. Vikram-S (VK-S) suborbital launch by M/s. Skyroot Aerospace Private Limited, Hyderabad launched on November 18, 2022.

e) Two satellites Thybolt-1 and Thybolt-2 have been registered as Indian Space Objects.

f) The Technical Centre and Design Centre is being established at IN-SPACe Headquarters, Ahmedabad to support NGEs in the design, development and realisation of space systems. The procurement actions are in the advanced stage and the delivery of the software and the test facilities are in progress.

g) The revised FDI policy for the space sector, the policy framework and guidelines addressing State's liability towards third-party damage arising due to Indian Space Objects, Differential pricing policy for various support extended to NGEs and the grant-in-aid scheme for the Indian Start-ups are proposed by IN-SPACe to develop the space ecosystem in the Country. These proposals are in various stages of approval and are expected to be rolled out soon.

h) IN-SPACe is pursuing an action plan towards formulation/adoption of standards for the space industry in India and thereby making them globally competitive.

i) IN-SPACe has been interacting with the media to create awareness among the public. The Twitter and LinkedIn handles are operational with over ~14,500 followers.

j) IN-SPACe coordinated the industry session of the G20 3^{d} Space Economy Leaders Meeting held in Indonesia. IN-SPACe participated in the International Astronautical Congress (IAC 2022) held in Paris from September 18-22, 2022. An India Pavilion was planned at IAC 2022 with participation from Indian space startups. A global networking forum session was organized on "Opening up of Indian space sector – Global perspectives" moderated by Chairman, IN-SPACe. The India-Australia space industry round table was facilitated by IN-SPACe on the sidelines of BSX 2022.

k) IN-SPACe is organizing the CANSAT-India 2022-23 competition organised by the Astronautical Society of India. The teams have been shortlisted based on the Preliminary Design Review. The competitions are planned to be conducted in June 2023. Dedicated Space Technology courses are introduced at IIT Bombay & IIT Madras.

03

Resource Management

3.1 Budget

Budget Overview

(₹ in Crore)

Sl No.	Particular	BE 2022-23	RE 2022-23	BE 2023-24
1	Establishment Expenditure	259.00	335.90	450.91
2	Space Technology	10534.50	7926.80	9440.66
3	Space Applications	1482.80	1283.23	1558.951
4	Space Sciences	206.11	117.00	138.80
5	INSAT Satellite Systems	418.59	452.10	531.00
6	Other Central Sector Expenditure	799.00	415.01	423.59
	Total	**13,700.00**	**10,530.04**	**12,543.91**

3.2 Human Resources

The total approved sanctioned strength of the Department as on March 1, 2021 is 20341, out of which 19,247 is sanctioned strength of ISRO Centres/Units & DOS. The sanctioned strength of autonomous units of DOS 1057. The change in the sanctioned strength of DoS is mainly due to (i) the transfer of administrative control of SCL to Meity along with resources and (ii) due to creation of additional posts under NSIL. 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 workplace is provided to the employees by schemes such as VISWAS and SAFE, a special scheme for assistance to families in an exigency, at a relatively low premium through internal trusts.

The key importance is laid to the competency requirements of the individuals, required for contributing effectively and efficiently towards the realisation of the organisational goals and resulting achievements. Hence stringent recruitment process is adopted to ensure quality personnel is inducted into the system, and greater importance is attached to the continuous development of human resources, periodically in tune with the programmatic requirements. Accordingly, the recruitment norms were revised during October 2022.

The Centralised recruitments & Centre Specific recruitments are resumed with revised recruitment norms in place. In line with GOI guidelines on mission mode recruitment, recruitment actions are initiated for filling up anticipated vacancies up to December 2023. Further, a plan of action for filling up the vacancies arising during 2024 is also being generated.

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 twelfth batch of students, who were admitted to B.Tech/dual degree during September 2018 at IIST, graduated during June 2022. A total of 89 eligible students are inducted in DOS/ISRO.

ISRO has established the 'Live Register' scheme, wherein 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 on the suitability and recommendations of Centres.

Training:

Training & Development activities are envisaged through both, Centralised and

3.2 Human Resources

Decentralised systems. The scheme of the Centralised Induction Training Programme for newly joined scientists/engineers, introduced in 2002, is being continued. The training programme is aimed at introducing the newly recruited scientists/engineers to ISRO systems by providing necessary exposure to the programmes, achievements, rules, regulations, systems, processes, etc. During 2022-2023, a total of 248 newly joined scientists/engineers were given induction training.

Similarly, Centralised Induction Training programs are being given to Office Assistants and Junior Personal Assistants in Administrative areas, conducted by different Centres/ Units on a rotational basis. Presently training for 351 newly recruited personnel is in progress.

Regarding induction training programmes for other categories of manpower, specific modules are designed, and training is imparted at respective Centres.

Other programmes such as;(i) Refresher courses for knowledge enhancement for technicians, technical assistants, and technical support staff; (ii) Special training programmes for Administrative staff covering rules, procedures, systems and covering latest changes in the system; (iii) Training programmes for scientific/technical staff on specific technical topics of relevance in specific centres/units; and (iv) Programmes on other relevant topics for other personnel, depending upon their specialization; (v) 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 decentralised training programmes.

Customised, exclusive management development training programmes for S&T personnel at the middle level & executive level are organised through leading academic institutes. ISRO also has been participating in academic programmes (SSP and SHSSP) conducted by the International Space University through nominations.

As part of the avenue for upskilling, ISRO has put in place sponsored education scheme where aspiring meritorious Scientists/Engineers can pursue higher studies, viz. ME/MTech & PhD through IISc, select IITs and IIST. Further, to scale up the upskilling requirements as well as in compliance with New Education Programme, ISRO has opened the scheme for acquiring masters through online programmes offered by institutes of national importance and IIST.

Capacity Building:

An internship Scheme in DoS/ISRO for external participants in line with New Education Policy is being implemented to encourage and instill scientific temperament in young minds.

INFORMATION AS ON 31.10.2022

Sl. No.	Details	Group-A		Group-B		Group-C	
A.	**GENERAL:** Total Number of Employees	Sci/ Tech Staff	Admn Staff	Sci/ Tech Staff	Admn Staff	Sci/ Tech Staff	Admn Staff
	(i) Male Employees	7500	264	2140	836	1085	1036
	(ii) Female Employees	1837	166	163	737	56	238
B.	**SCHEDULED CASTES/SCHEDULED TRIBES :**						
	(i) Number of Scheduled Caste Employees	621	55	370	237	168	249
	(ii) Number of Scheduled Tribe Employees	185	28	108	91	86	57
C.	**PERSONS WITH BENCHMARK DISABILITIES (PWBD):**						
	(i) Number of persons with Benchmark Disabilities existing						
	1. Blindness and low vision	10	0	1	9	2	12
	2. Deaf and hard of hearing	19	1	17	7	11	4
	3. Locomotor Disability including cerebral palsy, Leprosy Cured, Dwarfism, Acid Attack Victims and Muscular Dystrophy	128	12	75	38	22	9
	4. Autism, intellectual disability, Specific Learning Disability and Mental Illness	0	1	0	1	0	0
	5. Multiple Disability from amongst persons under clauses (a) to (d) including deaf-blindness in the posts identified for each disabilities	1	0	0	0	1	0
	(ii) Number of Persons with Benchmark Disabilities appointed during the year						
	1. Blindness and low vision	3	0	0	0	0	0
	2. Deaf and hard of hearing	6	0	0	0	0	0

3.2 Human Resources

Sl. No.	Details	Group-A		Group-B		Group-C	
	3. Locomotor Disability including cerebral palsy, Leprosy Cured, Dwarfism, Acid Attack Victims and Muscular Dystrophy	8	0	1	0	1	0
	4. Autism, intellectual disability, Specific Learning Disability and Mental Illness	0	0	0	0	0	0
	5. Multiple Disability from amongst persons under clauses (a) to (d) including deaf-blindness in the posts identified for each disabilities	0	0	0	0	0	0
D.	**EX-SERVICEMEN :**						
	(i) Number of Ex-servicemen existing	15	8	31	58	31	197
	(ii) Number of Ex-servicemen appointed during the year	0	0	0	0	1	4
E.	**OTHER BACKWARD CLASSES :**						
	(i) Number of OBCs existing	2181	75	1136	458	601	474
	(ii) Number of OBCs appointed during the year	42	2	6	0	10	2
F.	**ECONOMICALLY WEAKER SECTION (EWSs)**	7	0	2	0	4	2
G.	**MINORITIES**	529	64	281	195	100	151
H.	**APPRENTICES TRAINING:**						
	(i) Number of Apprentices trained during the year	1951					
	(ii) Number of successful apprentices out of (i) above	1303					
	(iii) Number of apprentices appointed as regular employees during the year against apprentice quota, if any.	0					

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

TABLE - I

Sl No	Centre/Unit	Total Strength of Employees 2022-23	Strength of SC Employees 2022-23	Strength of ST Employees 2022-23
1	DOS/ISRO HQ	400	51	25
2	VSSC	4583	358	43
3	URSC	2489	278	100
4	SDSC-SHAR	2115	330	120
5	SAC & DECU	1989	164	131
6	LPSC	1300	134	24
7	NRSC	827	108	42
8	ISTRAC	426	55	18
9	MCF	290	34	15
10	ADRIN	154	14	5
11	IIRS	110	11	4
12	PRL	270	12	8
13	NARL	70	11	1
14	NESAC	54	2	6
15	IIST	98	3	0
16	HSFC	213	6	4
17	IPRC	643	128	9
18	ANTRIX	16	1	0
19	NSIL	11	0	0
20	IN-SPACe	21	0	0
	TOTAL	**16079**	**1700**	**555**

3.2 Human Resources

STRENGTH OF PERSONS WITH DISABILITIES IN DOS/ISRO

TABLE - II

Sl No	Centre/ Unit	Total Strength of Employees 2022-23	Strength of Persons with Disabilities	Classification of Employees with Disabilites				
				Blindness & Low vision	Deaf and hard of hearing	Locomotor Disability including cerebral palsy, Leprosy Cured, Dwarfism, Acid Attack Victims and Muscular Dystrophy	Autism, Intellectual disability, Specific Learning Disability and Mental Illness	Multiple Disability from amongst persons under clauses (a) to (d) including deaf-blindness in the posts identified for each disabilities
1	DOS/ ISRO HQ	400	6	0	0	6	0	0
2	VSSC	4583	113	18	21	74	0	0
3	URSC	2489	68	9	17	42	0	0
4	SDSC-SHAR	2115	54	2	6	46	0	0
5	SAC & DECU	1989	42	2	6	34	0	0
6	LPSC	1300	34	1	7	24	0	2
7	NRSC	827	23	2	5	16	0	0
8	ISTRAC	426	15	0	0	15	0	0
9	MCF	290	2	0	0	2	0	0
10	ADRIN	154	8	0	0	6	2	0
11	IIRS	110	5	1	0	4	0	0
12	PRL	270	5	0	1	4	0	0
13	NARL	70	2	0	0	2	0	0
14	NESAC	54	2	0	0	2	0	0
15	HSFC	213	6	2	2	2	0	0
16	IIST	98	1	0	0	1	0	0
17	IPRC	643	13	0	0	13	0	0
18	Antrix	16	1	0	0	1	0	0
19	NSIL	11	0	0	0	0	0	0
20	IN-SPACe	21	0	0	0	0	0	0
	TOTAL	**16079**	**400**	**37**	**65**	**294**	**2**	**2**

STRENGTH OF REPRESENTATION OF EX-SERVICEMEN IN DOS/ISRO

TABLE - III

Sl No	Centre/Unit	Total Number of Employees in Group - C 2022-2023	Total Number of Ex-Servicemen in Group - C 2022-2023
1	DOS/ISRO HQ	77	5
2	VSSC	610	120
3	URSC	378	11
4	SDSC-SHAR	458	17
5	SAC & DECU	325	7
6	LPSC	205	41
7	NRSC	126	9
8	ISTRAC	46	5
9	MCF	49	2
10	ADRIN	19	2
11	IIRS	9	1
12	PRL	12	0
13	NARL	6	0
14	NESAC	3	0
15	HSFC	3	0
16	IIST	0	0
17	IPRC	86	13
18	Antrix	3	0
19	NSIL	0	0
20	IN-SPACe	0	0
	TOTAL	**2415**	**233**

3.2 Human Resources

WOMEN EMPLOYEES IN DOS/ISRO

TABLE - IV

Sl No	Centre/Unit	Total Number of Employees 2022-2023	Number of Women Employees 2022-2023	
			Scientific & Technical Staff	Administrative Staff
1	DOS/ISRO HQ	400	17	95
2	VSSC	4583	553	429
3	URSC	2489	566	137
4	SDSC-SHAR	2115	125	107
5	SAC & DECU	1989	255	74
6	LPSC	1300	98	103
7	NRSC	827	153	54
8	ISTRAC	426	76	33
9	MCF	290	29	12
10	ADRIN	154	31	8
11	IIRS	110	19	7
12	PRL	270	32	20
13	NARL	70	8	6
14	NESAC	54	8	4
15	HSFC	213	22	9
16	IIST	98	19	6
17	IPRC	643	42	33
18	Antrix	16	2	3
19	NSIL	11	1	1
20	IN-SPACe	21	2	0
	TOTAL	**16079**	**2058**	**1141**

Reservation for EWS (Economically Weaker Section) in civil posts in DOS/ISRO

TABLE-V

Sl No.	Centre/Unit	Total vacancies filled up for the period from 01.10.2021 to 30.09.2022	No. of EWS vacancies filled up for the period from 01.10.2021 to 30.09.2022
1	DOS/ISRO HQ	2	0
2	VSSC	3	1
3	URSC	0	0
4	SDSC-SHAR	42	0
5	SAC & DECU	0	0
6	LPSC	57	4
7	NRSC	0	0
8	ISTRAC	15	0
9	MCF	0	0
10	ADRIN	0	0
11	IIRS	0	0
12	PRL	3	0
13	NARL	2	0
14	NESAC	7	0
15	IIST	0	0
16	HSFC	0	0
17	IPRC	0	0
18	IN-SPACe	21	0
	TOTAL	**152**	**5**

3.3 Grant-in-aid

Grant-In-Aid of Rs. 10,00,000/- and above released to agencies during the calendar year 2022

Sl. No.	Programme Office	Sanction No. & Date	Name of the Grantee Institute	Purpose of Grant	Sanctioned amount
1	RESPOND	DS_2B-13012(2)/55/2018-Sec.II Dt: 20.12.2021, 25.08.2022 and 23.11.2022	Indian Institute of Science (IISc), Bengaluru	Release of grant for the ongoing Projects taken under Centre of Excellence (CoE) on Advanced Mechanics of Materials	1,50,20,000.00
2	RESPOND	B.19012/65/2015-Sec.2 Dt: 17.12.2021 & 03.03.2022	Indian Institute of Technology (IIT), Kharagpur	Release of grant for the Space Technology Cell (STC) activities at IIT, Kharagpur	1,43,16,000.00
3	RESPOND	DS-2B-13012(2)/29/2021-Sec.2 Dt: 20.12.2021	Indian Institute of Technology (IIT), Gandhinagar, Gujarat	Technology Development of RF Power LDMOS devices	19,93,000.00
4	RESPOND	B.19012/106/2015-Sec.2 Dt: 22.12.2021, 11.02.2022 & 06.12.2022	National Institute of Advanced Studies (NIAS), Bengaluru	Release of grant for NIAS Ph.D Programme for the year 2021-22	59,97,027.00
5	RESPOND	DS_2B-13012(2)/13/2020-Sec.2 Dt: 22.12.2021 & 25.08.2022	Indian Institute of Technology (IIT), Roorkee, Uttarkand	Release of grant for the Space Technology Cell (STC) activities at Indian Institute of Technology Roorkee	2,06,31,750.00
6	RESPOND	B.19012/96/2016.Sec.2 dt: 03.01.2022 & 25.08.2022	Indian Institute of Technology (IIT), Bombay, Mumbai	Release of grant for the Space Technology Cell (STC) activities at IIT, Bombay, Mumbai	3,44,03,750.00
7	RESPOND	DS-2B-13012(2)/25/2021-Sec.2 dt: 15.11.2021	Indian Institute of Technology (IIT), Indore, MP	Retrieval of hydrological parameters & development of glacio-hydrological model in Chandra Basin including satellite & field observations - 1st Year - 1s	13,33,750.00
8	SSPO	DS_2B-13013(2)/1/2020-Sec.2 dt: 15.12.2021	National Atmospheric Research Laboratory (NARL), Gadanki	Release of grant to NARL for the initiation activities related to payloads recommended for the future planetary exploration	27,00,000.00
9	RESPOND	B.19012/119/2016-Sec.2 dt: 19.01.2022	Current Science Association, Bengaluru	Publication Activities of Current Science Journal during 2021-22 - 2nd Installment	12,50,000.00

10	RESPOND	DS-2B-13012(2)/42/2021-Sec.2 dt: 10.01.2022	Jadavpur University, Kolkata	Multi-channel stackable input perfect reconstruction transmultiplexer for satellite communication - 1st year - 1st installment	11,93,000.00
11	RESPOND	DS-2B-13012(2)/20/2021-Sec.2 dt: 29.10.2021	Jyothy Institute of Technology, Bengaluru	Development of high temperature Fiber-Bragg Grating (FBG) strain sensors for static strain measurement upto 8000 C using optimisation of certain critical parameter before, during & post fabrication of FBGs - 1st year - 1st Installament	18,72,500.00
12	RESPOND (CBP)	DS_2B-13012(2)/14/2020-Sec.2 dt: 02.02.2022	National Institute of Technology (NIT), Tiruchirapalli	Release of grant for activities related to seven approved projects at Space Technology Incubation Centre (STIC), National Institute of Technology, Thiruchirappalli	65,46,833.00
13	RESPOND (CBP)	DS_2B-11011(3)/1/2021-Sec.2 dt: 17.02.2022	Vigyan Prasar, Noida	Department contribution for organizing "Vigyan Sarvatra Pujyate" under Azadi ka Amrit Mahotsav (AKAM).	2,00,00,000.00
14	RESPOND	DS_2B-13012(2)/7/2021-Sec.2 dt: 11.02.2022	Indian Institute of Technology (IIT), Delhi	Release of grant for the Space Technology Cell (STC) activities at Indian Institute of Technology Delhi - 2nd Installment	51,04,500.00
15	RESPOND	DS-2B-13012(2)/44/2021-Sec.2 dt: 12.01.2022	SASTRA Deemed University, TN	Development of compound semiconductors (III-V Nitride) based THz detectors for space applications - 1st Year - 1st Installment	11,66,250.00
16	RESPOND (CBP)	DS_2B-13012(2)/2/2022-Sec.2 dt: 02.02.2022	National Institute of Technology (NIT), Rourkela	Release of grant for initiating activities related to six approved Product Development/Innovative Projects at Space Technology Incubation Centre (STIC), National Institute of Technology, Rourkela (during the year 2021-22)	69,29,000.00

3.3 Grant-in-aid

17	RESPOND (CBP)	DS_2B-13012(2)/8/2020-Sec.2 dt: 18.02.2022	Dr. B R Ambedkar National Institute of Technology (NIT), Jalandhar	Release of grant for Infrastructure development at Space Technology Incubation Centre (STIC), Dr. B R Ambedkar National Institute of Technology, Jalandhar	29,39,760.00
18	RESPOND (CBP)	BDS_2B-13012(2)/11/2019-Sec.2 dt: 17.02.2022	National Institute of Technology (NIT), Agartala	Release of grant for progress of activities related to approved Technology Development Proposals (TDP) at Space Technology Incubation Centre (STIC) at NIT, Agartala during the year 2021-22	21,58,088.00
19	SSPO	B.19013/3/2016-Sec.2 dt: 23.02.2022	Inter University Centre for Astronomy & Astrophysics (IUCAA), Pune	Release of Grant for funding to the ASTROSAT Support Cell at IUCCA	16,91,197.00
20	RESPOND	B.19012/24/2014-Sec.2 dt: 02.03.2022	Savitribai Phule Pune University (SPPU), Pune	Joint Research Programme (JRP) at savitribai Phule Pune University 2021-22 - 2nd installment	70,77,750.00
21	RESPOND	B.19012/104/2016-Sec.2 dt: 02.03.2022 & 25.08.2022	Indian Institute of Technology (IIT), Madras	Release of grant for the Space Technology Cell (STC) activities	2,46,19,750.00
22	RESPOND (CBP)	DS_2B-13012(2)/11/2022-Sec.2 dt: 22.02.2022	Visvesvaraya National Institute of Technology (VNIT), Nagpur	Release of grant for initiating activities related to 3 approved Product Development/Innovative Project at Space Technology Incubation Centre (STIC) at VNIT, Nagpur during 2021-22	12,38,160.00
23	RESPOND (CBP)	BDS_2B-13012(2)/9/2022-Sec.2 dt: 18.02.2022	Maulana Azad National Institute of Technology (MANIT), Bhopal	Release of grant for initiating activities related to 3 approved Product Development/Innovative Project at Space Technology Incubation Centre (STIC) at MANIT, Bhopal during 2021-22	10,27,500.00

24	RESPOND	DS-2B-13012(1)/4/2022-Sec.2 dt: 09.03.2022	Central University of Jammu, Jammu	Setting up of Satish Dhawan Centre for space Science at Central University of Jammu	2,04,48,494.00
25	RESPOND	B.19012/85/2015-Sec-2 dt: 04.03.2022	Indian Institute of Science (IISc), Bengaluru	Release of grant for the Space Technology Cell during the FY 2021-22 - 2nd installment	1,34,66,500.00
26	RESPOND	B.19012/54/2015-Sec.2 dt: 16.03.2022 & 08.12.2022	Indian Institute of Technology (IIT), Kanpur, UP	Release of grant for the Space Technology Cell (STC) Activities	90,57,046.00
27	RESPOND	"DS-2B-13012(2)/13/2022-Sec.2 Dt: 25.02.2022"	Charotar University of Science & Technology (CHARUSAT), Gujarat	Experimental Simulation of Lightning & Development of Lightning Detection Antenna for Future Planetary Missions - 1st Year - 1st Installment	28,78,870.00
28	RESPOND	DS-2B-13012(2)/10/2022-Sec.2 dt: 22.02.2022	Indian Institute of Technology (IIT), Gandhinagar, Gujarat	Ultra-high sensitivity tunable laser-based spectroscopic gas detection system for the Human Spaceflight Programme - 1st Year - 1st Installment	27,00,000.00
29	SSPO	DS_2B-13013(2)/3/2022-Sec.2 dt: 08.03.2022	Aaryabhatta Research Institute of Observational Sciences (ARIES), Nainital	Release of grants towards the activities of Aditya-L1 Support Cell - 1st year - 4th qrtr	15,00,000.00
30	RESPOND	DS-2B-13012(2)/14/2022-Sec.2 dt: 25.02.2022	Indian Institute of Science, Education & Research (IISER), Bhopal, MP	Modelling of Buried Channel MOSFET - 1st year - 1st Installment	23,88,620.00
31	RESPOND	DS-2B-13012(2)/36/2021-Sec.2 dt: 30.06.2022	Indian Institute of Technology (IIT), Palakkad	Design and fabrication of inorganic electrochromic devices using layer engineering - 1st Year - 2nd Installment	10,08,750.00
32	SSPO	DS_2B_13013(1)1/2019-Sec.2 dt: 12.07.2022	Homi Bhabha Centre for Science Education (TIFR), Mumbai	Release of grant for supporting Indian School students team participating in International Olympiads in Astronomy & Astrophysics during FY 2022-23	35,83,000.00

3.3 Grant-in-aid

33	RESPOND	DS_2B-13012(2)/26/2022-Sec.2 dt: 25.08.2022	Indian Institute of Technology (IIT) (Banaras Hindu University), Varanasi, UP	Release of grant for the 10 new projects taken under Regional Academic Centre for Space at IIT(BHU), Varanasi - 1st Year - 1st Installment	1,28,64,260.00
34	RESPOND	DS-2B-13012(2)/27/2022-Sec.II dt: 09.09.2022	Indian Institute of Technology (IIT), Jodhpur, Rajasthan	To Study potential protocols for satellite based secure quantum communication under ambient atmospheric conditions - 1st year - 1st installment	15,96,730.00
35	RESPOND	DS_2B-13012(2)/1/2019-Sec.II dt: 08.09.2022	Global Academy of Technology, Bengaluru	Integrated geospatial approach for sustainable water management - study of Bengaluru - 3rd Year	11,41,800.00
36	RESPOND	DS_2B-13012(2)/62/2019-Sec.II dt: 25.08.2022	National Institute of Technology (NIT), Kurukshetra	Project Under Regional Academic Centre for Space at National Institute of Technology Kurukshetra - 1st year - 1st Installment	16,35,960.00
37	RESPOND	DS-2B-13012(2)/4/2022-Sec.2 dt: 15.09.2022	Amrita vishwa Vidyapeetham, Coimbatore	Analysis of throat film cooling for Semicryogenic Thrust chamber - 1st Year - 1st Installment	13,36,000.00
38	RESPOND	DS_2B.13012(2)/8/2021 dt: 24.08.2022	Indian Institute of Technology (IIT), Guwahati, Assam	Release of grant for the STC activities at IIT Guwahati during the year 2021-22	36,69,210.00
39	RESPOND	DS_2B-13012(2)/6/2021-Sec.2 dt: 07.10.2022	Malaviya National Institute of Technology (MNIT), Jaipur	Release of grants for activities of Regional Academic Centre for Space (RAC-S) at MNIT, Jaipur - 2nd Installment	21,84,648.00
40	RESPOND	DS-2B-13012(2)/28/2022-Sec.2 dt: 10.10.2022	Indian Insitute of Technology (IIT) (ISM), Dhanbad, Jharkhand	Abiotic synthesis of methane at the recess of Martian crust & prospect of microbial life in the Noachian Mars - Constraints from experimental & meteorite studies - 1st year - 1st Installment	17,12,500.00

41	RESPOND	DS_2B-13012(2)/53/2018 dt: 07.10.2022	Central University of Jammu, J&K	Release of grants for JRFs & Ras at Satish Dhawan Centre for Space Science at CUJ - for the year 2022-23	14,66,050.00
42	RESPOND	DS-2B-13012(2)/24/2021-Sec.2 dt: 23.11.2021	National Institute of Technology (NIT), Calicut, Kerala	Development of Model for generation of high-resolution gridded population map - 1st Year - 2nd Installment	10,54,500.00
43	RESPOND	DS_2B-13012(2)/41/2018-Sec.II dt: 14.11.2022	Indian Institute of Science (IISc), Bengaluru	1 Projects taken under Centre for Nano-Science & Engineering (CeNSE) - 1st Year - 1st Installment	46,77,000.00
44	RESPOND	DS-2B-13012(2)/48/2019-Sec.II dt: 24.11.2022	Jyothy Institute of Technology, Bengaluru	Thermal Management of Space Electronics using Multi-turn Pulsating Heat Pipes (PHP) - 2nd Year - Extension upto Dec-2022	12,22,560.00
					27,28,02,063.00

04

Others

4.1 Space in Parliament

Indian Space Programme continued to attract the attention of both Houses of Parliament. Questions were answered in Parliament during January 2022 – December 2022, as shown below:

Questions	Budget Session 2022		Monsoon Session 2022		Winter Session 2022		Total	
	8th Session of 17th Lok Sabha	256th Session of Rajya Sabha	9th Session of 17th Lok Sabha	257th Session of Rajya Sabha	10th Session of 17th Lok Sabha	258th Session of Rajya Sabha	LS	RS
Starred Questions	0	0	01	01	01	01	2	2
Unstarred Questions	21	18	06	07	12	07	39	32
Total	**21**	**18**	**07**	**08**	**13**	**08**	**41**	**34**

The Questions were with respect to Directorate of IN-SPACe, Launching of Chandrayaan-3, Space Debris, Private Player in ISRO, Private Players in Space, Self Reliance in Space Sector, Launch of Satellite EOS-04, Regulation of Projects by ISRO, Special Space Programme, Protecting India's interest in Space, Mission Gaganyaan, ISRO Assets, Observation Satellite EOS-04, Infrastructure Facilities of ISRO, Indian Space Associate, Promotion of Start-ups/Private Companies, Development of Space Science, Development of ADR for Space Debris, Launch of Satellites, ISRO Space Missions, Performance of Satellite Programmes, Spacecraft launched by the country, Launch of IsPA for broadband Services, Commercialization of Space Technology, Gaganyaan Programme, Status of Second Space Station at Thoothukudi in Tamil Nadu, Private Industry Players engaged in Space Exploratory Activities, Commercial Space Policy, Threats posed by Space Debris, Status of Mars Mission, Managing Space Debris, Finalization of Space Programmes, Active Debris Removal (ADR) Technology, Missions of ISRO, India-Singapore Technology Summit, Space Centre at Central University, Jammu, Earth Observation Satellite (EOS) Series, Opening up of Space Sector to Private Players, Kalpana Chawla Centre for Research, Private participation is Space, Earth Observation Satellites, India's share in Global Space Market, Programme of Department of Space, Launch of PSLV-C53, Atmanirbhar Bharat, Global Space Economy, Directives for Private Indian Space Industry, Scheme for Young Entrepreneurs in Space Sector, Status of Space Port at Kulasekharapattinam, Tamil Nadu, Space Tourism in the Country, Private Start-ups in Space Technology, Project Posts in ISRO, Indian Regional Navigation Satellite System, Space Applications Centre in ISRO, India Regional/Navigation Satellite System, Autonomous Precision Landing of Space Rockets, Integration of Systems, Developing Navigation System, Space Projects in Ladakh, Launch of Vikram Rocket, Research Programme in Space, Private Sector Participation in Space Sector, Private Players in Space Research, Delay in Launch of Chandrayaan-3, Setting-up NESAC, First test flight of Gaganyaan, Construction of Space Launch Centre, New Space Policy for Private Players Participation, Setting up of permanent station on the Moon, Budget for Space Research, Successful Launch of Foreign Satellites, Space Port in Tamil Nadu, Space Technology Startups, Foreign Collaboration in Space Exploration, Scientific evidence to India's History.

4.2 Vigilance

Annexure-1

Category of employees	Types of cases	Cases pending as on 01.10.2021	Cases received during the period 01.10.2021 to 30.09.2022	Total (Col. 3+4)	Disposed during 01.10.2021 to 30.09.2022	Pending (Col. 5-6)
1	**2**	**3**	**4**	**5**	**6**	**7**
Group-A & Group B (Gazetted) & Group-A (Non-Gazetted)	Disciplinary (Non-Vigilance)	13	5	18	4	14
	Disciplinary (Vigilance)	1	-	1	-	1
Group-B (Non-Gazetted) & Group C	Disciplinary (Non-Vigilance)	9	10	19	5	14
	Disciplinary (Vigilance)	1	0	1	1	0
	TOTAL	**24**	**15**	**39**	**10**	**29**

Annexure-2

Sl. No.	Particulars	
1.	Number of complaints of sexual harassment received during the period 01.10.2021 to 30.09.2022	**17**
2.	Number of complaints disposed during the period 01.10.2021 to 30.09.2022	**12**
3.	Number of workshops on awareness prorammes against sexual harassment conducted during the period 01.10.2021 to 30.09.2022	**14**

4.3 Progressive use of Hindi

This year also, the implementation of Hindi and all other programs in the Department of Space (DOS) continued with vigor. Official Language Implementation Committee held its quarterly meetings to review the progress in the use of Hindi. DOS/ISRO and its Units and Centres have also participated in the meetings of Town Official Language Implementation Committee (TOLIC) constituted in their respective towns. Modern communication tools and techniques were used for meetings/reviews.

- A meeting of the newly constituted Joint Hindi Advisory Committee (JHAC) of Department of Space (DOS) & Department of Atomic Energy (DAE) was held on April 9, 2022 at Vigyan Bhavan, New Delhi. Action Taken Report on the minutes of meeting has been prepared on the points pertaining to the Department of Space. A proposal for organizing the second meeting has been sent.
- The 43rd meeting of the Central Official Language Implementation Committee was held on February 15, 2022 through video conferencing under the Chairmanship of Secretary, DOL. Additional Secretary, DOS and Joint Director (OL), DOS participated in this meeting.
- Responsibilities of holding Town Official Language Implementation Committee (TOLIC) Secretariat are being undertaken by URSC, Bengaluru and MCF, Hassan of the Department.
- All the Centres/Units of the Department located in 'A', 'B' and 'C' regions have achieved the target prescribed for correspondence by the Department of Official Language.
- During the year, Department and its Centres/Units purchased Hindi books for Library in accordance with the target set up by DOL.
- During the year, Department has issued advertisements in English and regional languages along with Hindi.
- In order to implement Hindi in a more meaningful and effective manner and to evaluate the progressive use of Hindi in DOS/ISRO Units/Centers, an Annual Inspection Program for the year 2021-22 was drawn up by Department. This year these inspections are carried out in offline mode.
- Internal inspections of various Sections of DOS/ISRO HQ and also its Units/Centres were carried out to increase the use of Hindi in day-to-day work. Sections in DOS/ISRO HQ doing the best implementation of the Official Language were awarded on the occasion of World Hindi Day.
- Training Programs in Hindi under Hindi Teaching Scheme through online mode were continued in the Department. The percentage of employees having a working knowledge of Hindi in all DOS/ISRO Units/Centres is more than 80 percent. An action plan has been prepared for imparting training at the earliest to the remaining employees of Units/Centers within the time limit prescribed by DOL.

- Hindi Day, Hindi Week, Hindi Fortnight/Hindi Month and Hindi Workshops were organised in all DOS/ISRO Units/Centers, wherein competitions in Essay Writing, Noting and Drafting, Crossword, Simple Translation, Dictation, Calligraphy, Hindi Typing, General Knowledge Quiz, Solo Singing etc., have been conducted. These competitions have been organised for Hindi-speaking and non-Hindi speaking employees separately. The prizes have also been awarded separately for each category. In this connection, various Hindi competitions were conducted for family members/children of the employees.
- In order to implement the recommendation of the Joint Hindi Advisory Committee regarding the **propagation of "Hindi from house-to-house"**, family members of the employees were also included during Hindi Month celebrations in all Centers/ Units of the Department and there was an overwhelming response.
- World Hindi Day was celebrated on January 10, 2023 in all Center/Units of the Department through various Programs. On this occasion, various competitions have been organised separately for Hindi-speaking and non-Hindi speaking employees. Memory Test, What Picture Speaks and Indradhanush: A Multi Dimensional competition were conducted. Along with this, a special workshop was conducted on **'Training for work in Hindi on computers'** for Non-Gazetted staff of the Administrative area.
- The Department always plays an active role in the activities of Town Official Language Implementation Committee (TOLIC). It conducts various Programs under the auspices of Town OLIC. This year, on October 14, 2022, a 'Noting & Drafting' competition was conducted by the Department for the member offices of TOLIC (O-2), Bengaluru in Antariksh Bhavan. Also, many of DOS/ISRO HQ employees participated in the competitions conducted by the other member offices and won prizes.
- The 14th edition of 'DISHA', the in-house magazine of DOS/ISRO HQ was published 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 Centres/Units are advised for issuing the magazines digitally.
- Several pamphlets, panels/posters, brochures etc. pertaining 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 English as well as in Hindi. At present, revamping work of the website has been completed and Hindi translation of the English content is done regularly.
- **'Annual Incentive Scheme'** under which the officers/employees doing maximum work in Hindi during the Hindi month are awarded continued during the year. The

4.3 Progressive use of Hindi

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 and Certificates.

- Intended to encourage the Scientists of the Department to write books on Scientific subjects in Hindi, **'Vikram Sarabhai Hindi Maulik Lekhan Yojana'** continued during the year. This year, Department has received 06 (six) books from various Units/Centres of DOS/ISRO. After the review process, further action is going on for the publication of these books by concerned Units/Centres.
- As per the directives of DOL, during September 14-15, 2022, Hindi Day and Second All India Official Language Conference was organised at Pandit Deendayal Upadhyay Indoor Stadium, Surat, Gujarat and 62 nominated officers/employees from Units/Centers of DOS/ISRO participated in this conference. They all benefitted from the various OL sessions held during the conference.
- The second Sub-Committee of the Committee of Parliament on Official Language carried out an inspection on the progressive use of Official Language at MCF, Bhopal (inspection held at Indore), NRSC, Hyderabad, VSSC, Thiruvananthapuram and RRSC (Central), Nagpur on March 2, 2022, June 17, 2022, September 28, 2022 and January 19, 2023 respectively.
- In the Department the task of inclusion of Hindi in **COINS** and the web version of **COWAA** is underway at SDSC, SHAR, Sriharikota.

OL Orientation Program

- An Official Language Orientation Program was successfully organised by Human Space Space Flight Centre (HSFC), Bengaluru during June 22-24, 2022 for all the OL staff of DOS/ISRO Units/ Centres. During the occasion, sessions on the Application of Hindi in MS Word, preparation of various OL reports, and a Technical Talk on the Human Space Flight Program were conducted and a Kavi sammelan was organised with a view to bringing out the talent in budding Poets among the Hindi cadre in the Department.
- Orientation Program was conducted at DOS/ISRO HQ on October 13, 2022, wherein identified OL co-ordinators from various Sections/Divisions/Directorates/Offices of DOS/ISRO HQ were given important information pertaining to filling Quarterly Progress Reports. In this program, as a faculty Shri M G Som Shekharan Nair, Joint Director (OL), DOS gave a talk through point-wise PPT on Quarterly Progress Report proforma. During the Program, the queries and doubts of participants were resolved.

Workshop on 'Kanthasth Translation Tool'

- DOS/ISRO HQ conducted a one-day training workshop on **'Kanthasth Translation Tool'** on August 17, 2022 by considering the need for translation at offices. In this workshop, personnel of OL cadre from various Units/Centres of DOS/ISRO participated. Shri Shashipal Singh, Joint Director, AAI, C-DAC, Pune was invited as a faculty to impart the training in the workshop. Along with him Shri Mayank Raj, Program Engineer, C-DAC, Pune was also present for assistance.

Hindi Technical Seminar

- Every year, various Centres/Units of the Department conduct Technical Seminars in Hindi on various subjects. In these seminars, a session on Official Language is also included. Souvenir is also brought out in electronic/book form. During the year, the following Centres/Units of the Department organised Hindi Technical Seminars:-

Sl. No.	Centers/Units	Date	Topic
1.	Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram	February 10-11, 2022	**Technical Session:** Future direction of space research and applications in India **OL Session:** Specialities of Hindi in present scenario
2.	Space Application Centre (SAC), Ahmedabad	April 7, 2022	**Technical Session:** Planetary Exploration and Human Space Program in Indian prospectives
3.	National Atmospheric Research Laboratory (NARL), Gadanki	August 1, 2022	**Technical Session:** Weather, Climate, Space Science and Technology
4.	ISRO Telemetry, Tracking & Command Network (ISTRAC), Bengaluru	November 4, 2022	**Technical Session:** Make in India: Opportunities and challenges in Indian Space Program **OL Session:** Role of OL in materialising the concept of self- reliant India
5.	Indian Institute of Science & Technology (IIST), Thiruvananthapuram	November 25, 2022	**Technical Session:** Recent advances in Space research opportunities for Innovation and Incubation

4.3 Progressive use of Hindi

AWARDS:

National Level :

- For the Best implementation of the Official Language, Department of Space was awarded the ***"Rajbhasha Kirti Puraskar" (First Prize)*** for the year 2021-22 by the Hon'ble Minister of Home & Co-operation of India, Shri Amit Shah. The award was felicitated during the Hindi Divas and Second All India OL Conference organised at Pandit Deendayal Upadhyay Indoor Stadium, Surat, Gujarat during September 14-15, 2022.

Regional Level :

- The following Centres/Units of DOS were awarded for the best implementation of OL Hindi at their regional level during the year:-

Sl. No.	Centers/Units	Region	Award	Year
1.	Regional Remote Sensing Centre (RRSC-W), Jodhpur	'A'	Third	2020-21
		'A'	First	2021-22
2.	North-East Space Application Centre (NE-SAC), Shillong	'C'	First	2020-21
3.	Regional Remote Sensing Centre (RRSC-S), Bengaluru	'C'	First	2020-21

TOLIC Level :

- The following Centres/Units of DOS were awarded for best implementation of OL Hindi by their respective Town Official language Implementation Committee (TOLIC) during the year:-

Sl.No.	Centres/Units	Region	Award	Year
1.	Indian Institute of Science & Technology (IIST), Thiruvananthapuram	'C'	Third	2020-21
			Second (For In-House Magazine)	2020-21
2.	Regional Remote Sensing Centre (RRSC-S), Bengaluru	'C'	Second	2020-21
3.	North-East Space Application Centre (NE-SAC), Shillong	'C'	Second	2020-21
4.	ISRO Telemetry, Tracking & Command Network (ISTRAC), Bengaluru	'C'	Second	2020-21
			Second	2021-22
5.	Physical Research Laboratory (PRL), Ahmedabad	'B'	First	2021-22

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, the 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)/CPSE(NSIL) 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, the Department of Space has published the following information on the web page: https://www.isro.gov.in/RTI.html

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
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
5. DOS Employees – CCA Rules – Amendment April 2022

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 advice 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

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 agencies 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.

1. The Department of Space does not give any concession or issue any permit/authorization.

4.4 Right to Information

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
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
    5. DOS Employees – CCA Rules – Amendment April 2022
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.

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 2022 to March 2022
    2. April 2022 to June 2022
    3. July 2022 to September 2022
2. Telephone numbers and addresses of the Secretary and other Officers/Officials of the 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 the RTI Act, 2005 (2021-2022)
5. Details of tender bids awarded, names of suppliers, rates, and the 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. ISRO's Timeline from 1960s to Today

During the period December 2021 to November 2022, **2614** applications were received and information was disseminated under the provisions of the RTI Act. **253** Appeals were received by the First Appellate Authority and **32** appellants approached the Second Appellate Authority, i.e., Central Information Commission.

4.5 Audit Observations

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 1st 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.02 of 2018 (Para No.7.1) Operationalisation of Satellite navigational system	One	Nil	Nil	Nil	Nil
2	Report No.02 of 2018 (Para No.7.2) Infructuous expenditure on Software Development	One	Nil	Nil	Nil	Nil
3	Report No.6 of 2020 (Para No.5.1) Grant of additional increments	One	Nil	Nil	Nil	Nil
4	Report No.6 of 2020 (Para No.5.2) Silicon carbide mirror development facility	One	Nil	Nil	Nil	Nil
5	Report No.6 of 2020 (Para No.5.3) Creation of posts without approval of competent authority	One	Nil	Nil	Nil	Nil

			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 1st 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**
6	Report No.6 of 2020 (Para No.5.4) Residency period for promotion fixed at lower than prescribed level	One	Nil	Nil	Nil	Nil
7	Report No.6 of 2020 (Para No.5.5) Management of civil works	One	Nil	Nil	Nil	Nil

05

Milestones & Acronyms

5.1 Milestones

1962

- Indian National Committee for Space Research formed and the 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 was 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 the 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

5.1 Milestones

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 the INSAT-2 series, launched (December 7, 1995)
- Launch of the 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

5.1 Milestones

2008

- PSLV-C10 successfully launched 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 the Chandrayaan-1 spacecraft on October 22, 2008
- European Ariane-5 launch vehicle successfully launched W2M satellite on December 21, 2008, jointly built by Antrix / ISRO and EADS Astrium on a commercial basis

2009

- PSLV-C12 successfully launched 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 launched 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 launched 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 launched 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, was 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 was successfully launched by Ariane-5 VA-214 from Kourou, French Guiana, on July 26, 2013
- India's advanced communication satellite GSAT-7 was 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 launched 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.

5.1 Milestones

- 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. The 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 launched 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
- Geosynchronous Satellite Launch Vehicle (GSLV-D6), equipped with the indigenous Cryogenic Upper Stage (CUS), successfully launched 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 the USA – were also launched by this PSLV flight
- The 3164 kg GSAT-15 carrying Ku-band transponders and GAGAN payload was 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 five other 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 the USA, Canada, Germany, and Indonesia, as well as two satellites (SATHYABAMASAT and SWAYAM) from the 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 a 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

5.1 Milestones

- 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's 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 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, the Republic of Korea, the UK and the USA.
- GSLV-F08, in its 12th flight as a 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 for a Crew Escape System, a critical human spaceflight technology. 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 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 the 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 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 the 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

5.1 Milestones

- On December 11, 2019, PSLV-C48 successfully launched RISAT-2BR1satellite 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. Out of 18 co-passengers, four were from IN-SPACe and the remaining from 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

2022

- On February 14, 2022, PSLV-C52 injected Earth Observation Satellite EOS-04, a Radar Imaging Satellite designed to provide high-quality images under all weather conditions, into an intended sun-synchronous polar orbit. It also placed a student satellite, INSPIREsat-1 and a technology demonstrator satellite, INS-2TD, which is a precursor to India-Bhutan Joint Satellite (INS-2B).
- On June 22, 2022, GSAT-24, a communication satellite weighing 4180 kg with Pan India coverage for meeting DTH applications, was launched successfully through Arianespace. It was the first Demand Driven mission by NSIL, post space reforms.
- On June 30, 2022, PSLV-C53 launched three satellites DS-EO satellite, NeuSAR satellite, and SCOOB-I satellite. All satellites belonged to Singapore. This was the second dedicated commercial mission of NewSpace India Limited (NSIL). This mission performed PSLV Orbital Experimental Module (POEM) activity to conduct scientific experiments using the spent PS4 stage as an orbital platform. It was first time that the PS4 stage would orbit the earth as a stabilized platform.
- On August 7, 2022, the first developmental flight of a small satellite launch vehicle (SSLV) was conducted. The vehicle could not place the satellites into 356 km circular orbits but placed in 356 km x 76 km elliptical orbit and thus fell short of its target.
- On October 23, 2022, LVM3 placed 36 satellites of OneWeb in their intended orbits. This was a dedicated commercial mission for a foreign customer through NSIL. This was one of the biggest commercial orders executed by ISRO. With this launch, the LVM3 enters into the global market in a grand manner.
- On November 18, 2022, the first launch of a launch vehicle built by a private company in India was accomplished. Vikram-S, a suborbital launch vehicle from M/s Skyroot Aerospace Pvt. Ltd., Hyderabad, was launched successfully from SDSC, Sriharikota.

- A private launchpad and mission control center was established within the ISRO campus at SDSC SHAR, Sriharikota, for the first time. The launchpad is designed and operated by a private company, an Indian space-tech start-up, Agnikul. It was inaugurated by Chairman ISRO, on November 25, 2022
- On November 26, 2022, PSLV-C54 successfully launched the EOS-06 satellite along with eight nanosatellites into two different SSPOs. The mission used two Orbit Change Thrusters (OCTs) introduced in the Propulsion Bay Ring of the Vehicle to achieve two different orbits. Nanosatellites included the India-Bhutan Satellite

5.2 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
DISHA	Disturbed and quiet-time Ionosphere-thermosphere System at High Altitudes
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

5.2 Acronyms

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 Mk-III	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
IN-SPACe	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

5.1 Acronyms

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

5.1 Acronyms

	Management System
POEM	PSLV Orbital Experimental Module
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 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
SCORPIO	Satellite Based Cyclone Observation for Real-time Prediction over Indian Ocean
SDSC SHAR	Satish Dhawan Space Centre Sriharikota High Altitude Range
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
SSLV	Small Satellite Launch Vehicle
SSPA	Solid State Power Amplifier
SSPO	Sun-synchronous Polar Orbit
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, Tracking & Commanding
TTC	Telemetry, Tracking 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

5.1 Acronyms

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