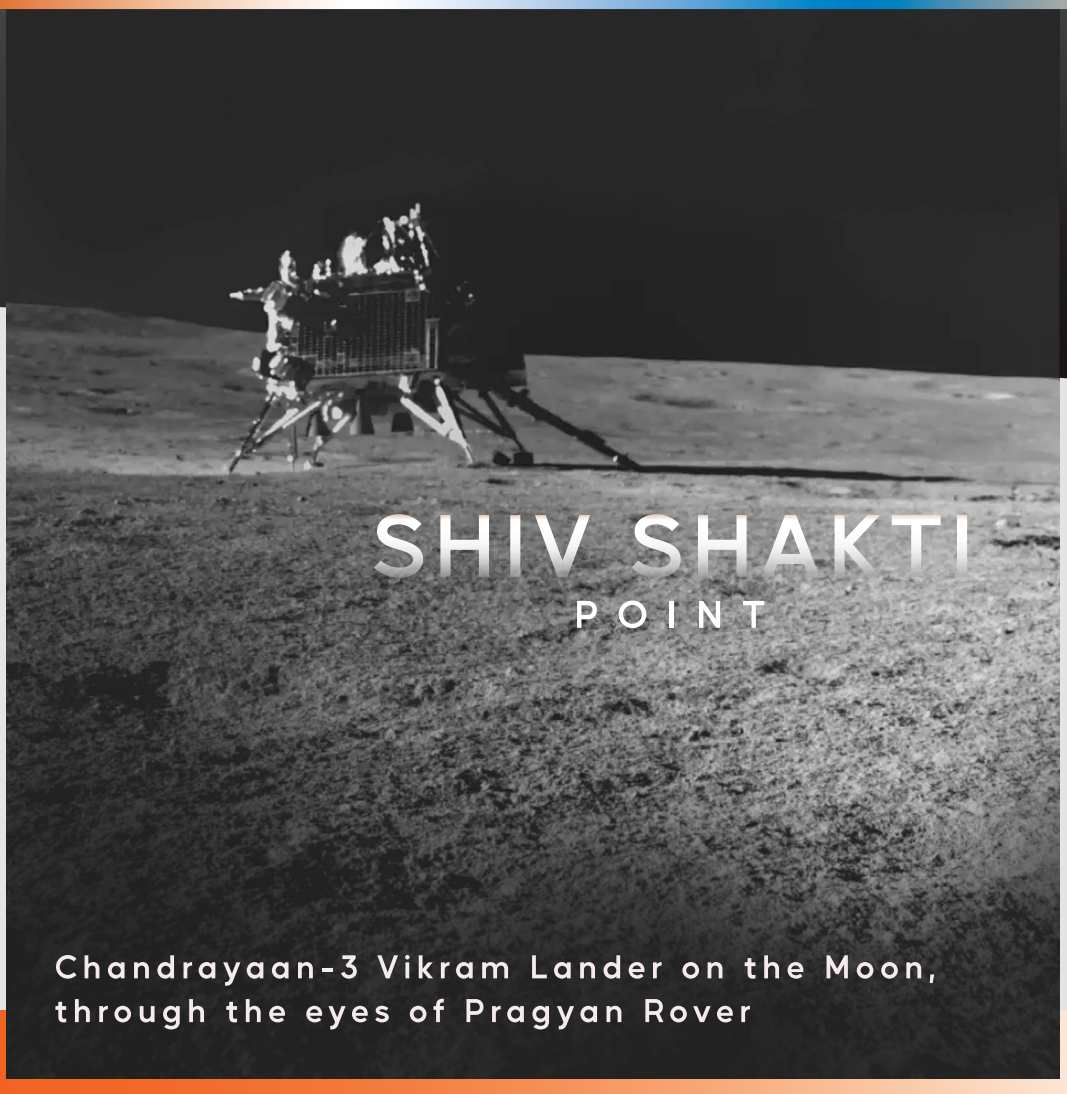
भारत सरकार
अंतरिक्ष विभाग

सत्यमेव जयते

GOVERNMENT OF INDIA
DEPARTMENT OF SPACE



Chandrayaan-3 Vikram Lander on the Moon,
through the eyes of Pragyan Rover

वार्षिक रिपोर्ट Annual Report

2023-2024

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अंतरिक्ष विभाग

GOVERNMENT OF INDIA
DEPARTMENT OF SPACE

वार्षिक रिपोर्ट
Annual Report

2023-2024

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3. Resource Management

4. Others

5. Milestones & Acronyms

Space Missions

(As per Financial Year)

Mission	2022-23	2023-24	2024-25
Earth Observation Satellites	4	1	4
Communication Satellites	1	0	1
Navigation Satellites	0	1	1
Space Science Satellites	0	3	0
Technology Demonstrator	0	3	5
PSLV	2	4	5
GSLV MkII	0	2	2
LVM3	2	1	1
SSLV	2	0	1
Gaganyaan	0	0	2
TOTAL	11	15	22

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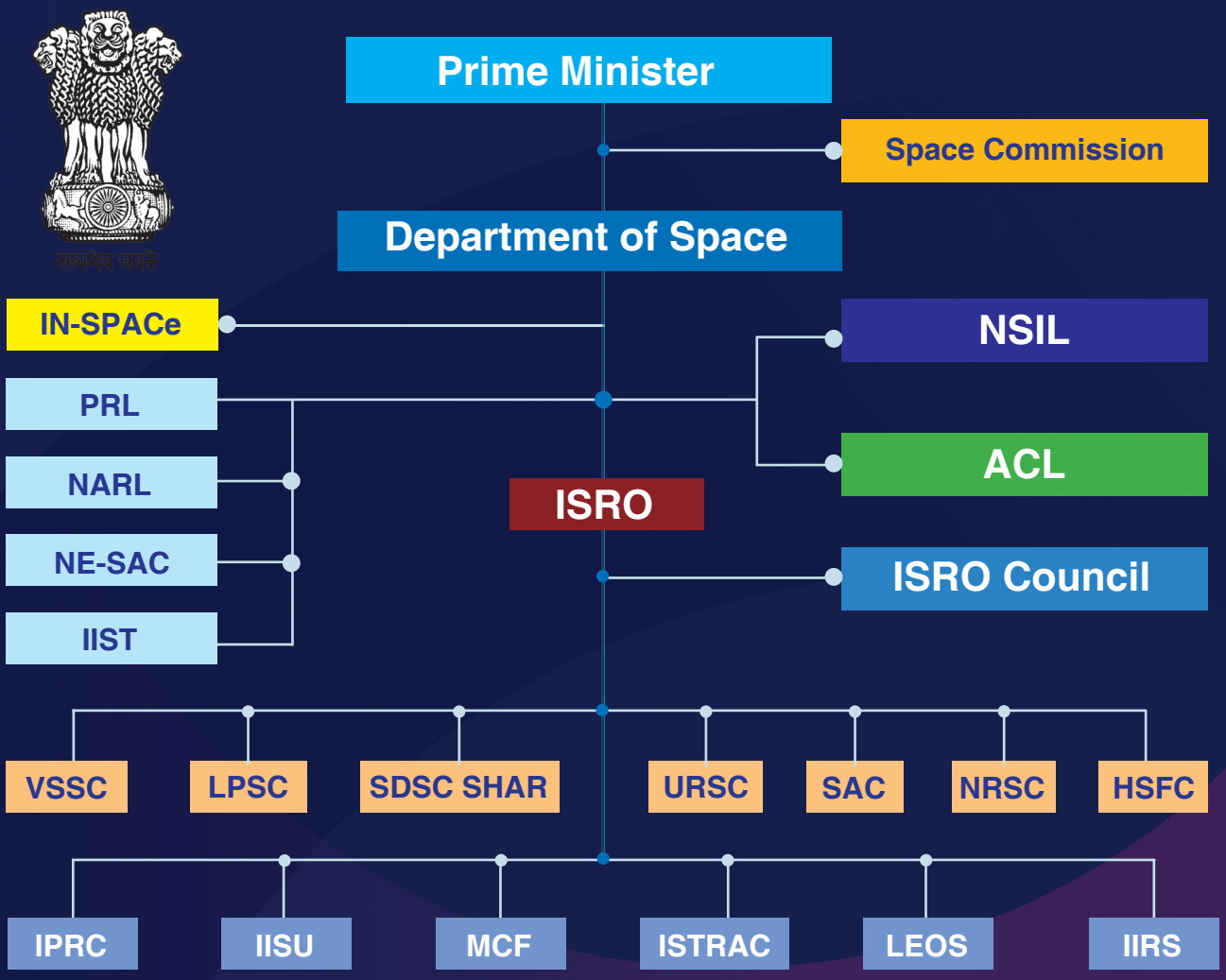
Organisation Chart



ACL	Antrix Corporation Limited
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

Space activities in the country were launched with the setting up of the Indian National Committee for Space Research (INCOSPAR) in 1962. Work on the 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 the 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 programmes like satellite communication, earth observation, navigation, launch vehicle, space science, disaster management support, sponsored research schemes, 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


VSSC Main Building at Veli Range Complex

Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram

VSSC is the lead Centre of ISRO, responsible for the design and development of launch vehicles and associated technologies. Major programmes at VSSC include Polar Satellite Launch Vehicle (PSLV), Geosynchronous Satellite Launch Vehicle (GSLV), Geosynchronous Satellite Launch Vehicle MkIII (LVM3), Small Satellite Launch Vehicle (SSLV) and Rohini Sounding Rockets. PSLV, GSLV and LVM3 are already in the operational phase. VSSC has core competence in multiple disciplines and pursues advanced research & development in cutting-edge technologies for space transportation systems, overall project management of all launch vehicles, enabling space industry ecosystem, technology transfer and academic interface. VSSC houses state-of-the-art facilities in the design, development, realisation and testing of launch vehicles.

VSSC also pursues advanced research and development including Reusable Launch Vehicles (RLV), Test Vehicles for flight demonstration of new technology elements and design concepts, air-breathing propulsion systems, and critical technologies towards the Gaganyaan programme including Human Rated Launch Vehicle (HLVM3), crew module structure, Deceleration and ECLSS systems.

URSC

URSC Main Building

U R Rao Satellite Centre (URSC), Bengaluru

URSC is the lead Centre for design, development, and realization of communication, navigation, remote sensing, scientific and Interplanetary missions. Over the past five decades, specialized teams of scientists, engineers and technicians of URSC have built around 124 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. with the support of administrative personnel.

URSC is also involved in research and development activities of cutting-edge satellite technologies, total management of all satellite missions, creation of a vibrant space industry for the realization of space systems, technology transfer, academia interface, etc. The Centre also houses ultra-modern design, development, fabrication and testing facilities for satellites. URSC is functioning in its sprawling 32 acres main campus, adjacent to NAL, HAL Airport Road and 110-acre ISRO Integration & Testing Establishment (ISITE) campus at Marathahalli, 8 km away from the main campus.

SDSC

Satish Dhawan Space Centre (SDSC) SHAR

Satish Dhawan Space Centre (SDSC)-SHAR, Sriharikota

SDSC, the "Spaceport of India", is the backbone of the Indian Space Research Organization in providing launch base infrastructure for the Indian Space Programme. During the present year, all the launch complex facilities are activated and utilised to their full capacity 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 foreign satellite customers.

LPSC

LPSC (Bengaluru)

LPSC (Valiamala)

Liquid Propulsion Systems Centre (LPSC), Thiruvananthapuram/Bengaluru

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

LPSC activities and facilities are spread across its two campuses viz., LPSC, Valiamala / Thiruvananthapuram and LPSC, Bengaluru/Karnataka. The activities in its campus at Valiamala include design and development entities for earth storable, cryogenic, semicryogenic and electric propulsions systems. The end to end design, development and realisation of flow control components and modules, advance manufacturing and proto fabrication entities, project teams, management systems activities, as well as R&D activities in the area of propulsion and structure are carried out by expert entities. LPSC activities in its campus at Bengaluru include design and realisation of propulsion systems for Earth Observation, Communication, Navigation satellites and other scientific missions. Also, development and production of transducers & sensors are undertaken here. A new campus at Tumkuru is also being established for Integrated Titanium alloy Tank production and Mono propellant thruster test facility.

SAC


SAC Main Campus


SAC New Bhopal Campus


SAC Bhopal Technical Campus


Delhi Earth Station

Space Applications Centre (SAC), Ahmedabad

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

Human Space Flight Centre (HSFC), Bengaluru

HSFC is responsible for end-to-end mission planning, development of engineering systems for crew survival in space for short- and long-term missions, involvement in crew selection and training, and initiating activities for sustained Human Space Flight missions. HSFC will focus on the development of engineering systems related to the Orbital Module, human-centric technology domains of Bioastronautics, Crew training and Life support, basic and applied space sciences, human and robotic space exploration, space habitats and gateways etc. HSFC will also play the role of a technology aggregator to bring together national expertise in diverse disciplines for multi-directional growth and capacity.

NRSC

National Remote Sensing Centre

National Remote Sensing Centre (NRSC), Hyderabad

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 a hired facility at Old Airport, Begumpet and five Regional Remote Sensing Centres (RRSCs) in Bengaluru, Jodhpur, Kolkata, Nagpur and Delhi for promoting remote sensing applications for various states. Main Campus is at Balanagar, Hyderabad for 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 aircraft operations are carried out from the old airport, Begumpet.

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, Bhoonidhi and NDEM are the geoportals of NRSC for the dissemination of satellite data and geo-spatial products and services in the country. Outreach facility at Jeedimetla in Hyderabad for providing training for professionals, faculty and students and for general outreach.

IPRC

ISRO Propulsion Complex

ISRO Propulsion Complex (IPRC), Mahendragiri

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

ISTRAC


ISRO Telemetry Tracking and Command Network

ISRO Telemetry Tracking and Command Network (ISTRAC), Bengaluru

ISTRAC, a unit of ISRO, is entrusted with the primary responsibility of providing TTC and mission control services to major Launch Vehicle and LEO and Interplanetary Spacecraft missions of ISRO. It has the additional responsibility of operating the complex Ground Segment of NavIC. ISTRAC is 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 telemedicine, Village Resource Centres and tele-education. ISTRAC is also entrusted with Space Situational Awareness Activities (SSA) and setting up observational and data analysis facilities for space debris management.

In order to realize these objectives, ISTRAC has established a network of ground stations, 5 stations at Bengaluru, 3 stations at Lucknow, 2 stations each at Mauritius, Sriharikota, Port Blair, Biak, 1 station each at Thiruvananthapuram, Brunei and 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 missions. 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 5 IRNSS CDMA Ranging stations (IRCDR) and 16 IRNSS Range and Integrity Monitoring stations (IRIMS). ISTRAC has also established the ISRO Navigation Centre-1 (INC-1), including an IRNSS Network Timing (IRNWT) facility at Bengaluru and ISRO Navigation Centre-2 (INC-2), including an IRNWT facility at Lucknow.

MCF

Master Control Facility

Master Control Facility (MCF), Hassan

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

The facilities located at Hassan and Bhopal together now take care of 29 Spacecraft (20 in GEOSAT class and 9 in IRNSS class) with payloads classified into communication, meteorological and navigational categories. These satellites are placed between 32.50°E and 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

ISRO Inertial Systems Unit (IISU), Thiruvananthapuram

IISU 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

Laboratory for Electro-Optics Systems (LEOS), Bengaluru

LEOS is a premier unit of ISRO responsible for the design, development and realization of state-of-the-art attitude and navigation sensors, high-performance optics and special-purpose science instruments. A large number of these ingeniously developed sensors and optical systems have been successfully flown in various missions of the Indian Space Programme. Demand-driven indigenous developments include Star Sensors, Earth Sensors, Sun Sensors, Magnetometers, Large-area high-precision telescope mirrors, Multi-band matched opto-mechanical lens assemblies, Thin-film and Special purpose coatings, Fiber optic gyroscopes, Laser and Fiber optics-based navigation sensors, MEMS devices, speciality detectors, ground and on-board software. It also includes a spectrum of in-house metrology instruments that are developed or procured and ground-calibrated for this purpose. The multitude of sensors, optics and photonic devices developed at LEOS are embedded into various aspects of satellite attitude determination, remote sensing, meteorological applications, scientific exploration, interplanetary missions, etc.


Indian Institute of Remote Sensing

Indian Institute of Remote Sensing (IIRS), Dehradun

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

The capacity building activities of the Institute are primarily grouped into the following three domains – (1) Training & Education (2) Research and (3) Outreach. The Institute also hosts and provides support to the Centre for Space Science and Technology Education in Asia and The Pacific (CSSTEAP), affiliated to the United Nations, to conduct the remote sensing and GIS training & education programmes at postgraduate level.

PRL

Physical Research Laboratory

Physical Research Laboratory (PRL), Ahmedabad

Physical Research Laboratory is mandated to conduct fundamental research in niche areas of sciences. Its research is organized in seven major science areas, namely, Astronomy & Astrophysics, Solar Physics, Space and Atmospheric Sciences, Planetary Sciences, Geosciences, Atomic, Molecular and Optical Physics, and Theoretical Physics. From April to November 2023, the scientists of PRL have published 113 peer-reviewed scientific papers in reputed journals.

NARL

National Atmospheric Research Laboratory

National Atmospheric Research Laboratory (NARL), Gadanki

NARL specializes in conducting frontline research on atmospheric, ionospheric & space weather, and planetary ionospheric sciences through observations, innovative technique/ technology, instrument development, and simulation/modelling. Currently more than 52 observational facilities are in regular operation at NARL, including MST radar, Rayleigh/ Mie lidar, Rayleigh Doppler lidar, Lower Atmospheric Wind Profiler (LAWP), digisonde, Gadanki Ionospheric Radar Interferometer (GIRI), X-band polarimetric radar, Airglow imager, GPS-sonde, network of GNSS receivers for total electron content and integrated water vapor, Instrumented towers, and radiation, aerosol and trace gases measuring instruments along with a 1.7 petascale High-Performance Computing (HPC) system.

NARL provides weather forecasts and high-resolution upper air wind data for supporting the rocket launchings at SDSC-SHAR. NARL has a vibrant research and development, Ph. D and PDF, capacity building, and public outreach programs.

NE-SAC

North Eastern Space Applications Centre

North Eastern Space Applications Centre (NESAC), Shillong

NESAC is an autonomous organization under the Department of Space (DOS) that has provided more than 23 years of dedicated service to the eight states of the North Eastern Region (NER) of India using space science and technology. The major objectives of the Centre are: 1) to provide an operational remote sensing and geographic information system-aided natural resource information base to support activities on development/management of natural resources and infrastructure planning in the region. 2) to provide operational satellite communication application services in the region in education, health care, disaster management support, and developmental communication. 3) to take up research in space and atmospheric science area and establish an instrumentation hub and networking with various academic institutions of NER. 4) to enable single window delivery of all possible space-based support for disaster management. 5) to set up a regional-level infrastructure for capacity building in the field of geospatial technology.

IIST


Indian Institute of Space Science and Technology

Indian Institute of Space Science and Technology (IIST), Thiruvananthapuram

Indian Institute of Space Science and Technology at Thiruvananthapuram, Kerala was established in 2007 to develop and discover possibilities of shaping manpower for Indian space programme. From its first steps in the alternate campus at VSSC, Veli in 2007, to the firm steps in Valiamala, IIST has evolved consistently, catalyzing and adapting to changes. In the sixteen years of its functioning, the institute has dynamically evolved and expanded as a centre of multidisciplinary learning and research that spans themes across the fields of Aerospace, Avionics, Chemistry, Earth and Space Sciences, Humanities, Mathematics and Physics. IIST offers undergraduate, postgraduate, doctoral and post doctoral programmes with a synergetic emphasis on Space Science & Technology applications.

ACL


Antrix Corporation Limited

Antrix Corporation Limited (ACL), Bengaluru

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

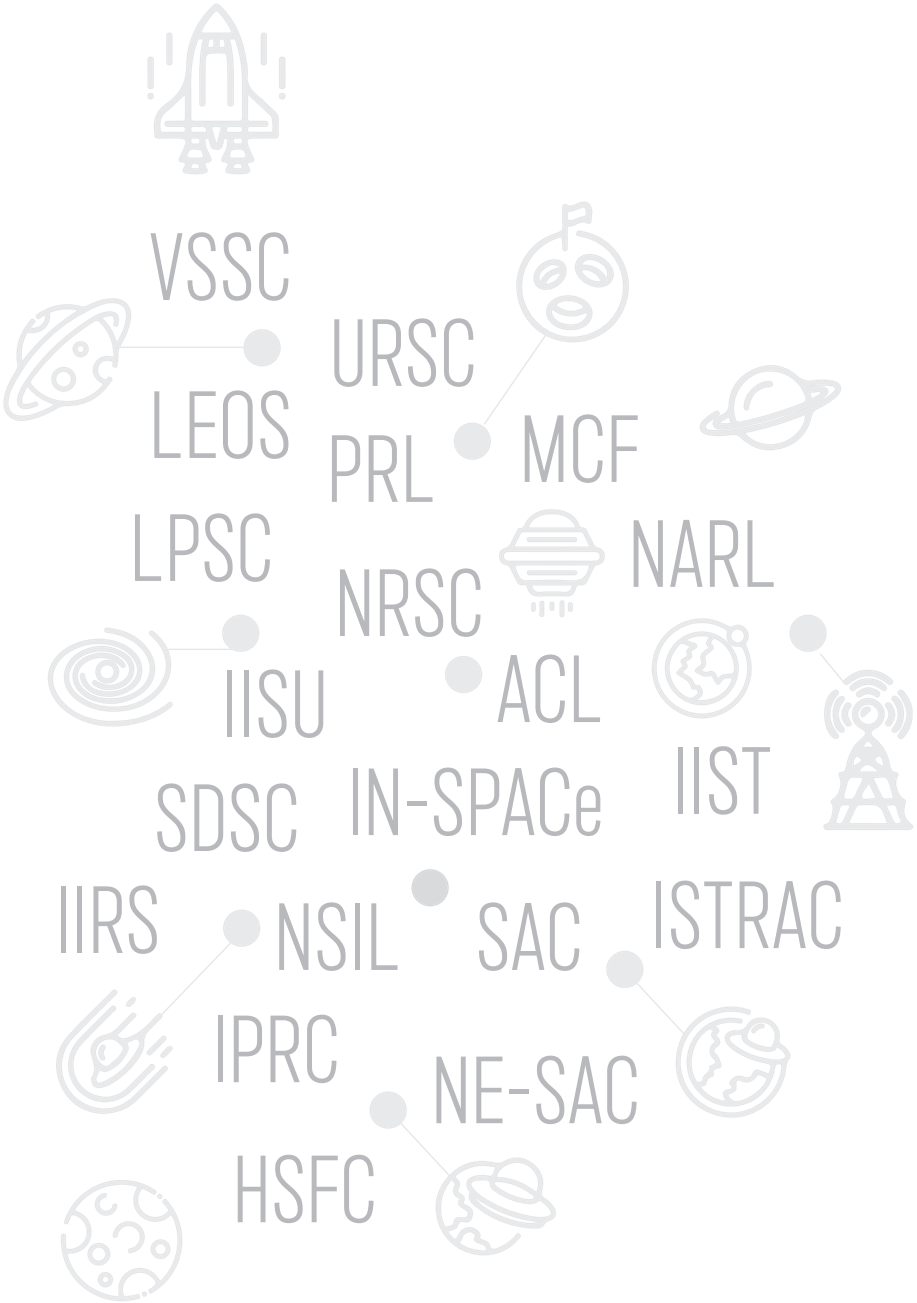
NewSpace India Limited (NSIL), Bengaluru

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), Ahmedabad

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 an autonomous nodal agency attached to 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 Entities (NGE), 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 a directorate in Bengaluru.


VSSC
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IPRC
NE-SAC
HSFC

02

Major Activities

2.1 Earth Observation, Data Processing, and Applications

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 systematic coverage of India and global data requirements of user community. Remote sensing data from different foreign satellites are also being received, processed & archived on SAN storage regularly. Numbers of Indian and foreign missions supported during the year 2023 are 15 and 9 respectively, acquiring around 10,494 passes and meeting > 99.8 % station efficiency.

IMGEOS: Integrated Multi-Mission Ground Segment for Earth Observation Satellites (IMGEOS) established at Shadnagar in 2011 with four 7.5M S/X-band antenna systems to receive data from IRS series of satellites. In 2022, the station has been augmented with one 7.5 M S/X antenna having tri-axis to handle zenith passes as well as 5 mission clashes, two 7.3 M S/Ka-Band Antenna Systems (2021 & 2022), One Ku-Band 9.1 M Antenna Systems respectively to cater the data acquisition for all earth observation missions of ISRO. Presently the station supports data reception from 24 satellites.

AGEOS: "Antarctica Ground Station for Earth Observation Satellites (AGEOS)" facility was established by ISRO in 2013 at Bharati Station, Antarctica in South Pole region for global data coverage with nearly 10-11 orbits visibility from each satellite. The station has two antenna systems one dual band (S/X) and one tri band antenna(S/X/Ka). The station is supporting Telemetry and Tele-command operations for all current IRS missions and payload data reception for EOS-06, EOS-04, Resourcesat-2/2A, Cartosat-2S and Cartosat-3. The data received from various Remote Sensing Satellites is transferred through high speed communication link to NRSC in near real time. The station is also supporting Launch and Early Orbit Phase (LEOP) operations of PSLV.

Antenna System Upgradation: Technology Development Projects

- Tri Band (S/X/Ka) Antenna System: The S/X/Ka Tri-band feed has been designed and developed in-house for data reception in all three frequency bands.
- Implementation of Servo Control loops on drive system for compact full motion antenna has been realized, verified on 7.5M antenna system and its tracking accuracy is within 100 milli-degree.
- Development of pointing error model for Program Tracking system of 7.5M antenna using Machine Learning Techniques - Model is evaluated by tracking the satellite pass using 7.5M antenna system. The targeted pointing accuracy of 100 milli-degree

achieved. Development of Model is completed and reached Technology Readiness Level (TRL)-5 stage.

- Implementation of Adaptive control in Tri axis Antenna - three variants of Adaptive control namely MIT, modified MIT and Lyapnov methods were modeled and analyzed and found that Modified MIT method is optimum in terms of meeting transient, steady state and tracking accuracy performance of 25 milli-degree for meeting Ka band tracking requirement.

Satellite Data Processing and Dissemination

It involves scheduling of satellite payloads for real time imaging, generating and disseminating data products to user community through Bhoonidhi portal. Twenty-four satellites (IRS and Non-IRS) are in operational phase. Customized and value added products are generated as per user requirements. New improved Application Ready Data (ARD) products from AWiFS, LISS-III, and EOS-04 (MRS) are operationalized. Data quality and Mission performance are periodically evaluated and informed to stake holders. Workshops, conferences and one-on-one meetings are conducted to enhance data utilization by user community.

Opening of IRS data on free basis under Space Policy 2023: One of the major announcement under the ambit of Indian Space Policy 2023 is to provide 'free and open' data access from Indian Remote Sensing (IRS) satellites of ISRO, in order to greatly enhance the use of data at national, regional and global levels and rendering multiple benefits to all the sector of the society. Accordingly, remote sensing data with 5 meters and coarser spatial resolution is now made accessible on 'free and open' basis to all for download through ISRO's EO data hub, named 'Bhoonidhi' https://bhoonidhi.nrsc.gov.in. The Portal enables access to extensive archive of remote sensing data & derived data, since 1988.

Data Processing, Products, Archival and Web Applications

Optical sensor data: About 6,40,150 satellite data sets were processed which are acquired from optical sensors of various Indian Remote Sensing (IRS) satellites. Around 2,68,558 data products were generated for the open data downloads from Bhoonidhi.

Microwave Sensor data: About 95,421 satellite data products were processed which are acquired from microwave sensors of various IRS satellites viz., RISAT-1A, SARAL, RISAT-2B & 2BR1, EOS-01 and Non IRS-NovaSAR.

2.1 Earth Observation, Data Processing, and Applications

Global Data Processing: About 1,21,563 global satellite data sets were processed which are acquired from various IRS & Non-IRS satellite missions viz, LANDSAT-8 & 9, S-NPP, JPSS-1, MODIS. Fire Alerts generated from Aqua, Terra, JPSS-1 and S-NPP are regularly disseminated immediately after the data acquisition. A new agreement with United States Geological Survey (USGS) has been signed to exchange the data of future Landsat and Resourcesat series.

Value Added Data products: Customized products have been generated for remote sensing application projects at national level which include - 27,293 value added products viz, weekly NDVI, High resolution merged satellite data (of varying spatial resolutions) for Integrated Watershed Management Programme (IWMP), NABARD, Space based Information Support for De-centralized Planning (SISDP), Atmospherically corrected National mosaics using 4,950 orthorectified AWiFS images from Resourcesat series of satellites and Value Added Data Services (VADS) products.

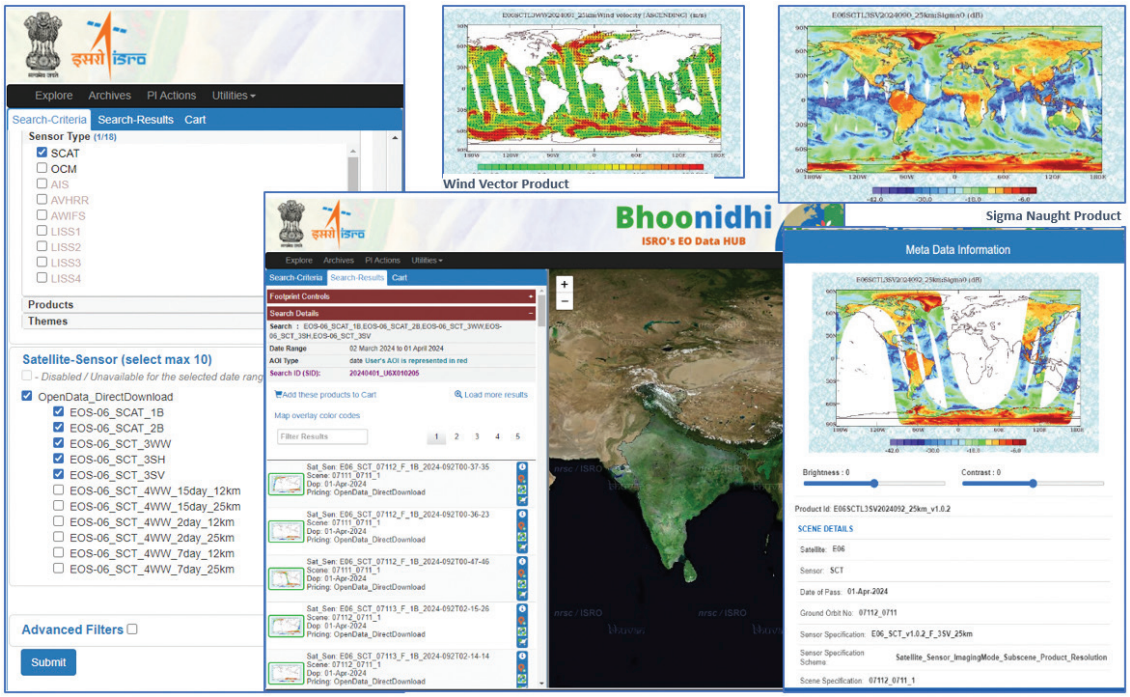
Satellite Data Dissemination: A total of 1,01,347 products were supplied during the reporting period. Besides, Foreign high/ medium resolution data of the order of 4,707 sq. km was disseminated to users. Prior to the implementation of Indian Space Policy for satellite data dissemination, the authorisation certificates were issued to users for procuring the data of 6,09,498 sq. km. from foreign satellites data providers/vendors.

UAV Data Acquisition and Processing: UAV data acquisition has been carried out for remote sensing applications such as Agroforestry & Horticulture, Agriculture, Soil properties, Disaster mitigation, Geosciences.

Improvements in Bhoonidhi Portal

Bhoonidhi Portal is catering to order & download as well as free dissemination of EO data & products as per the Indian Space Policy 2023. Some of the upgrades include:

- E0S-6: SCAT3 L4 Wind Vector products enabled at Bhoonidhi for browse, download and at Vista for visualization.
- New filter-based search feature was designed developed and released for users to make data more searchable. In order to guide the users towards using the application a new help page was designed, developed and deployed.
- Bhoonidhi-Vista - Near real time data visualization in native resolution: A new version of Bhoonidhi-Vista has been released with multi-layer visualization, animation and user-friendly features.



Bhoonidhi Webportal

- Bhoonidhi PLANNeR: Designed and developed this application allows users to submit request for fresh acquisitions and is now enabled for EOS-04 mission.

MOSDAC & VEDAS: Web Based Satellite Data Visualization, Archival & Dissemination Portals

Meteorological and Oceanographic Satellite Data Archival Centre (MOSDAC) is providing near real time satellite data to operational agencies within the country like 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) 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. Cyclogenesis and tracking of cyclone Biparjoy was carried out using Microwave Humidity Sounder (MHS) payload and Oceansat-3 Scatterometer.

2.1 Earth Observation, Data Processing, and Applications

Suitable framework for operationalization of Agri-Decision Support System (AgriDSS) has been developed on Visualization of Earth Observation Data and Archival System (VEDAS) platform. In this regard an MOU was signed between Department of Space (DOS) and Department of Agriculture and Farmer's Welfare (DAFW).

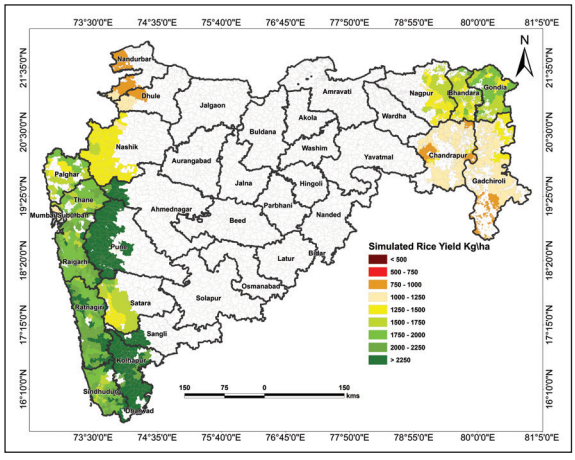
'Dashboard' for AgriDSS Drought portal as a part of AgriDSS development project was implemented and development activities related to "National Geospatial Drought Portal" on VEDAS Platform, as per GOI Drought Manual-2020 has also been completed. These portals have more than 10,000 registered users where more than 50,000 Data Products are hosted on monthly basis and are being utilized by users.

National Information system for Climate and Environment Studies (NICES)

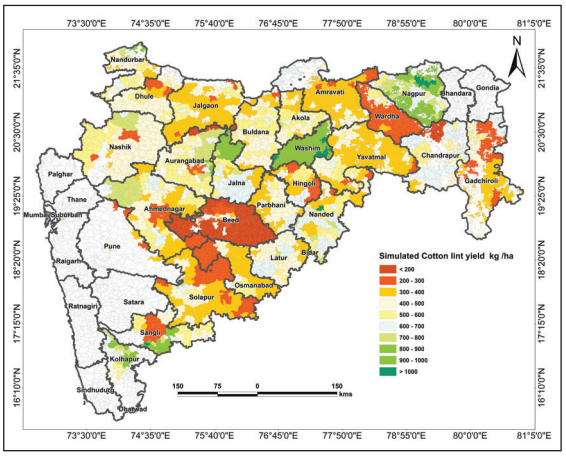
NICES is a multi-institutional venture with the participation of ISRO/DOS centres and national Institutions under various Ministries, which help to strengthen the information base with contributions (in-situ observational and model outputs) from the participating organisations. NICES has built a strong database of 70 geophysical variables pertaining to the land, ocean and atmosphere. Out of which 13 variables with potential to qualify as ECVs are being taken up in the current phase of NICES program. These products are disseminated through the NICES portal under the Bhuvan platform of ISRO.

Remote Sensing Applications

Agriculture: Towards a digital agriculture solution for Maharashtra state, circle-level yield estimation was done for rice and cotton crops for entire Maharashtra for 2022-23 season. Summer (zaid) crop mapping was carried out for 2022-23 season. Drought impact assessment was done using various spectral and weather indices. These inputs were used by the State government for drought declaration.



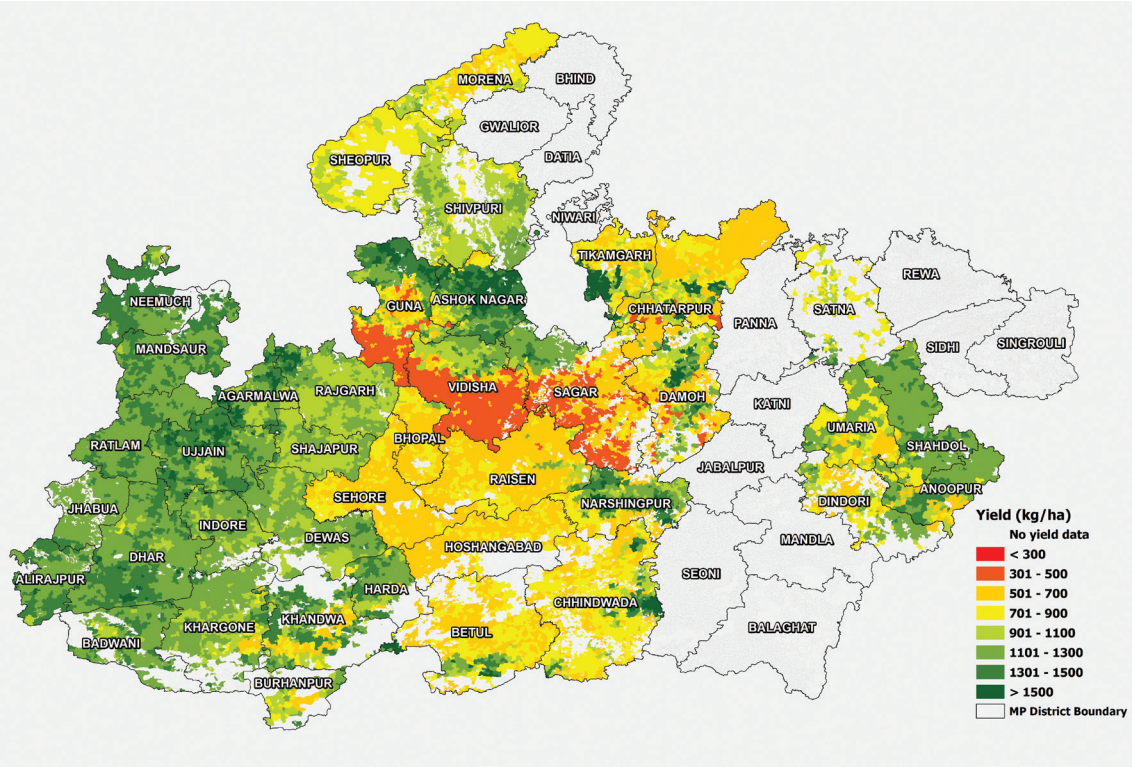
Rice yield map of Maharashtra



Cotton yield map of Maharashtra

Madhya Pradesh AgriGIS project aims to utilise different mapping and data analysis techniques to provide quantitative in-season measures related to crop growth and productivity. Deliverables from the project include GIS maps of sown area, crop specific area, crop damages and irrigation unit (IU) wise yield estimates. Yield estimation of major crops i.e., Soybean, Paddy (Irrigated, Rainfed), Wheat, Gram and Mustard are being carried out through trained ensemble machine learning models build at different cluster level. The models are trained using historical years yield data and validated with the current year's Crop Cutting Experiment (CCE) datasets.

Under **SUFALAM** (Space technology Utilization for Food Security AgricuLtural Assessment and Monitoring), green fodder yield has been estimated for four rabi-summer fodder types using a semi-physical model in the AMUL catchment consisting of Mahisagar, Kheda and Anand districts.



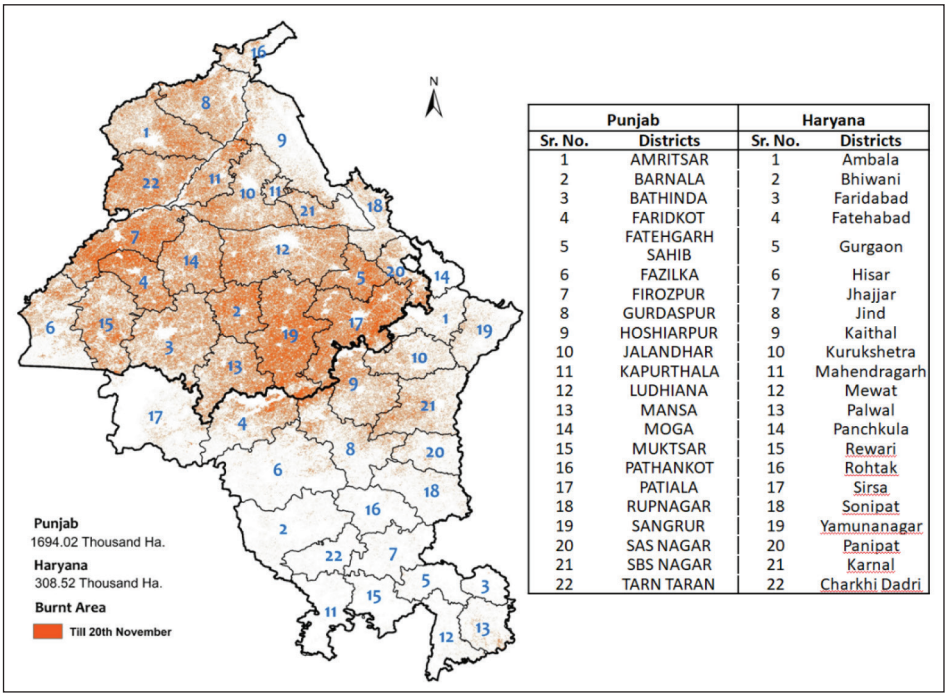
Machine learning based Soybean yield estimates (IU-wise) for Kharif 2022 in MP

Country-level crop mask was generated for computation of Soil Moisture Indicator (SMI) and shared with Mahalanobis National Crop Forecasting Centre (MNCFC) for implementation in Drought portal under Krishi-DSS.

Paddy stubble burnt area progression in Punjab & Haryana - Kharif 2023: Near real time satellite based detection of active fire locations is being done from Suomi-NPP VIIRS.

2.1 Earth Observation, Data Processing, and Applications

Continuous monitoring and assessment of the actual paddy stubble burnt areas and its weekly/fortnightly progression are being carried out for kharif 2023 for Punjab & Haryana states using the MIRBI index (Mid Infrared Burn Index) which utilizes a combination of two SWIR bands to estimate the burnt area.

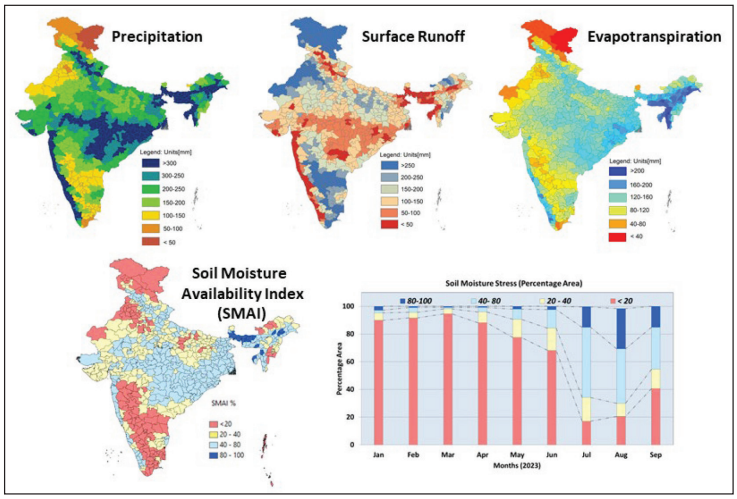


Punjab		Haryana	
Sr. No.	Districts	Sr. No.	Districts
1	AMRITSAR	1	Ambala
2	BARNALA	2	Bhiwani
3	BATHINDA	3	Faridabad
4	FARIDKOT	4	Fatehabad
5	FATEHGARH SAHIB	5	Gurgaon
6	FAZILKA	6	Hisar
7	FIROZPUR	7	Jhajjar
8	GURDASPUR	8	Jind
9	HOSHIARPUR	9	Kaithal
10	JALANDHAR	10	Kurukshetra
11	KAPURTHALA	11	Mahendragarh
12	LUDHIANA	12	Mewat
13	MANSA	13	Palwal
14	MOGA	14	Panchkula
15	MUKTSAR	15	Rewari
16	PATHANKOT	16	Rohtak
17	PATIALA	17	Sirsa
18	RUPNAGAR	18	Sonipat
19	SANGRUR	19	Yamunanagar
20	SAS NAGAR	20	Panipat
21	SBS NAGAR	21	Karnal
22	TARN TARAN	22	Charkhi Dadri

Geospatial map of rice stubble burnt area over Punjab & Haryana in 2023 till November 20, 2023.

Water Resources Applications: Under National Hydrology Project, the National modelling framework has been developed through geospatial and hydro-meteorological datasets, macro-scale Variable Infiltration Capacity (VIC) hydrological model at 3 min (5.5 km) grid level for the entire country.

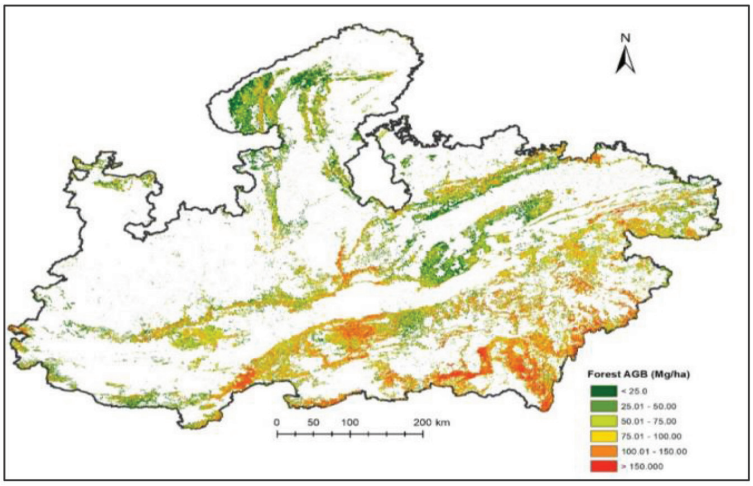
The modelling framework was used for computing water balance components (Soil Moisture, Evapotranspiration and Surface Runoff) for the period June to September 2023.



Seasonal Water Balance Components and Soil Moisture Availability Index of 2023.

All the envisaged deliverables entrusted to ISRO under NHP by MoJS have been developed and are shared with NHP-NPMU, in addition to web-dissemination. Some of the products/ services include Near Real time daily Actual Evapotranspiration (AET), Inventory of glacial lakes, Daily spatial snowmelt rate during April 01-June 30, 3-day snow-melt rate forecast, Spatial Flood Early Warning System for Godavari and Tapi Rivers, Hydrological Drought Indices, etc. NRSC/ ISRO is ranked as No.1 Central Implementing Agency since October 2021 as part of Monthly Ranking System by MoJS. A National Workshop was conducted in December 2023 to showcase the accomplishments and to deliberate future roadmap.

Forestry & Ecology Applications: EOS-04 C-band SAR data along with ALOS PALSAR-2 L-band data were used for forest biomass estimation in the Forest of Madhya Pradesh using 215 ground sample plots. Cross polarization backscatter was found to be strongly correlated with Above Ground Biomass (AGB) at both the frequencies. Synergistic utilization of C & L-band improve the accuracy of estimation in low-medium biomass regions.



Spatial Distribution for Forest above ground biomass for the state of Madhya Pradesh.

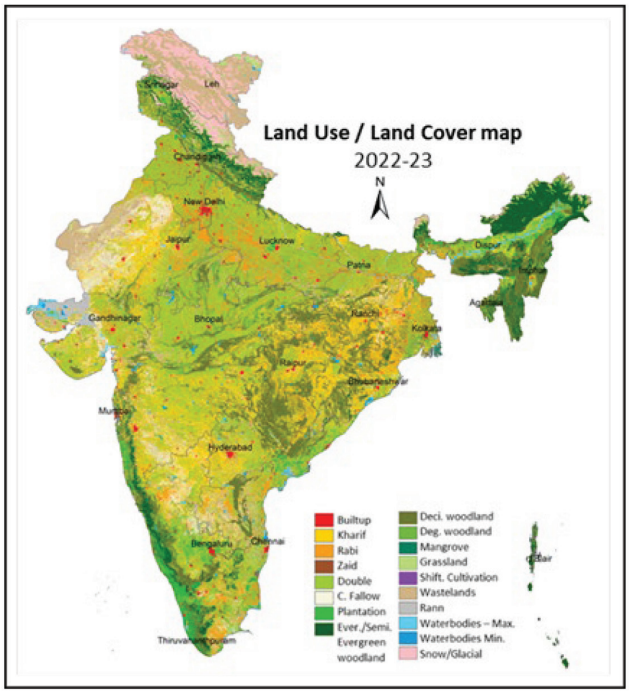
Identification of Long Duration Fire Events (LDFE): Design and development of automated methods for identifying LDFEs and rapid assessment of burnt area from the LDFEs using multi-sensor and multi-temporal satellite data, have been realized. A working prototype of the system has been operationally developed for Telangana and Odisha states.

Land Resources Applications: Under Natural Resources Census program 17th cycle (2022-23) of Land Use / Land Cover (LULC) database has been generated using IRS AWiFS data at 1:250k scale for the entire country. Season wise cropped area under Kharif, Rabi and monthly cropped area for August, September, December, February (2022-23) was also prepared. Analysis showed that there is increase in cropped area under Rabi and slight increase in Kharif crop as compared to previous year/s. Further increase is observed

2.1 Earth Observation, Data Processing, and Applications

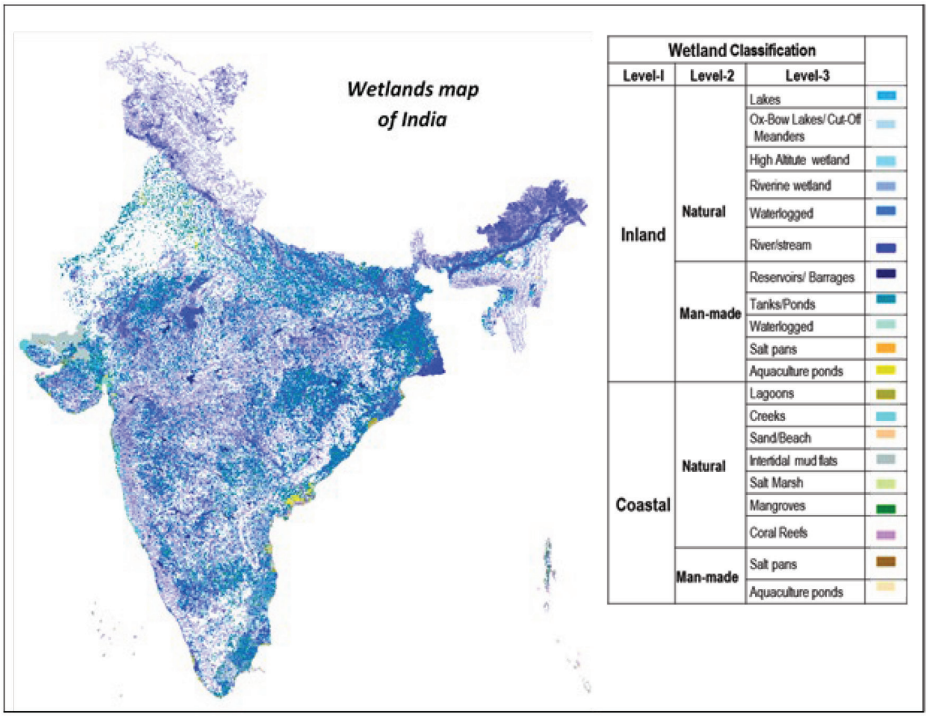
for area under Built-up and maximum waterbody and double/triple crop; whereas decrease is observed for area under wastelands and scrub forest class.

Wetland inventory: Country level geodatabase of high resolution wetlands prepared using Resourcesat-2/2A 5.8 LISS-IV data of 2018-19 and published on VEDAS web portal. This database contained information about 3.58 million numbers (area ≥ 0.1 ha) of wetlands across the country covering 16.89 mha area (5.12% of TGA of India).



Land use/ Land cover map (2022-23)

Rural Development: (i) Integrated Watershed Management Programme' (IWMP) Phase 2: A Memorandum of Understanding (MoU) has been entered into with the Department of Land Resources



Wetland Inventory of India

(DoLR) for the second phase of the "Integrated Watershed Management Programme" (IWMP) which is now amalgamated as the Watershed Development Component (WDC) of Pradhan Mantri Krishi Sinchai Yojana (PMKSY); also known as WDC 2.0.

(ii) Watershed Monitoring for NABARD Projects-Phase 2: Watershed Monitoring Project – Phase 2 for the National Bank for Agriculture and Rural Development (NABARD) has been completed. The positive outcomes of this partnership include improved financial support for rural projects, enhanced agricultural productivity, and strengthened economic resilience for the rural communities and internalization of geospatial technology for watershed programmes by the National Bank for Rural development.

REWARD (Rural Empowerment and Water Resource Development): Memorandum of Understanding (MoU) has been entered into with National Rainfed Area Authority (NRAA) under the REWARD Project to innovate and implement sustainable practices for water resource development, with a specific focus on empowering rural communities.

Urban Studies: Large scale urban geospatial database has been generated at 1:4,000 scale using very high resolution satellite (VHRS) data of 0.5m or better for 238 Cities (20 States / UTs) under AMRUT. These databases are being used for generation of various value added products/ information such as Rooftop Solar Power potential estimation, Rooftop Rain Water Harvesting Potential and Road Network Analysis, etc. (e.g. part of Siddipet City, Telangana).

Behest of Ministry of Housing and Urban Affairs (MoHUA), the responsibility of Urban geospatial database preparation for AMRUT-2 cities has been vested to National Remote Sensing Centre (NRSC).

Large scale urban geospatial database for part of Siddipet City, Telangana

Urban Water body Information System (UWaIS): In order to conserve and manage the water resources, the Urban Local Bodies (ULBs) are required to shortlist the water bodies. To aid the ULBs in this process, the naming of water bodies been completed by NRSC to

the extent of information available from the Open Source platforms. A web portal UWaIS with a backend geospatial database on the water bodies is also made functional.

Space based Information Support for Decentralized Planning - Update: SISDP-U project has achieved a major milestone of completing thematic data mapping updates for entire country at 1:10k scale. The project lead by Regional Centres, NRSC with active contribution of 27 state partner institutions, is a major initiative by ISRO for generation and updation of thematic data i.e. Land Use Land Cover, Drainage, Rail and Road and settlements layers for entire country.

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 during 2023 for 14 affected states in the country and more than 260 maps and value-added satellite images (with high-resolution satellite data analysis) were disseminated to disaster support organizations for flood disaster management support. RISAT-1A SAR MRS, CRS and FRS modes data were extensively utilized for pre & post flood scenario generation of preparation of spatial flood inundation maps in the country during 2023. International Charter Space and Major Disasters was activated 3 times during the floods due to Biparjoy Cyclone (June 2023), floods in North India (July 2023) and Glacial Lake Outburst Flood in Sikkim State (October 2023).

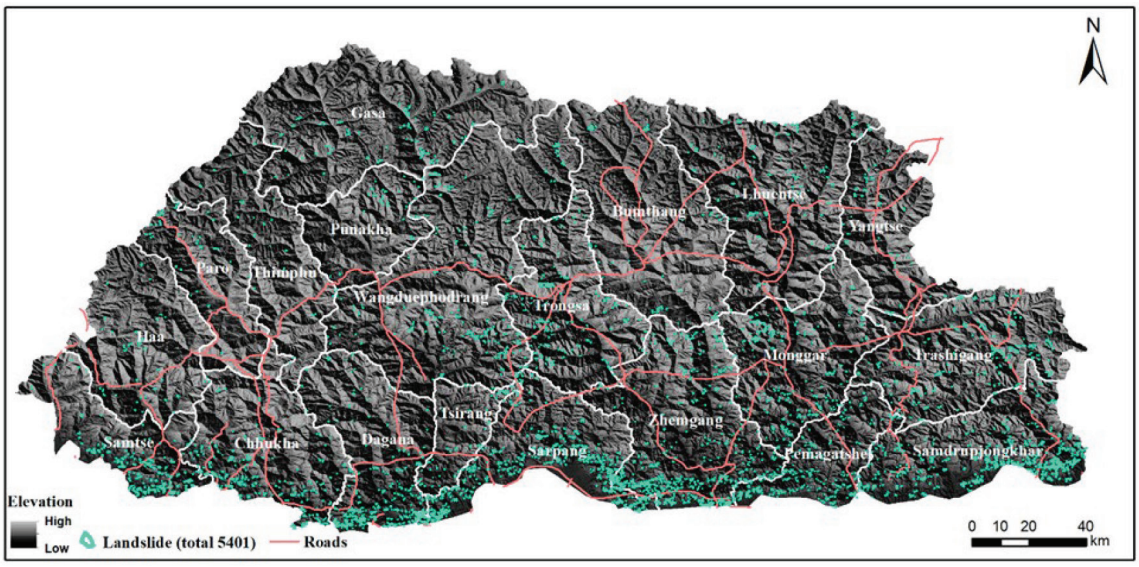
Flood Affected Area Atlas of India depicting cumulative flood inundation information during the last 25 years has been generated and released for use by central & state disaster management stakeholders. It is an important non-structural resource for flood damage mitigation, and is available in NDEM and NDMA portals for download.

Landslide Atlas of India prepared using inventory of landslides occurred during last 25 years in India has been released for use by concerned Disaster Management Stakeholders. About 80,000 landslide records occurred in 17 states and 2 UTs are reported in the Atlas, and are used for ranking the 147 districts in these State/ UTs for their risk exposure. The Atlas is available in NDEM and NDMA portals for download.

Landslide inventory mapping of Bhutan: The landslide inventory mapping of Bhutan was carried out using high-resolution remote sensing images (Resourcesat-2

and Resourcesat-2A: LISS-IV 5.8 m resolution) in correlation with cumulative rainfall (June to September) data.

A total of 5401 landslides were mapped using satellite data in Bhutan. This study will help in the future landslide mitigation program of Bhutan.



Landslide inventory map of Bhutan

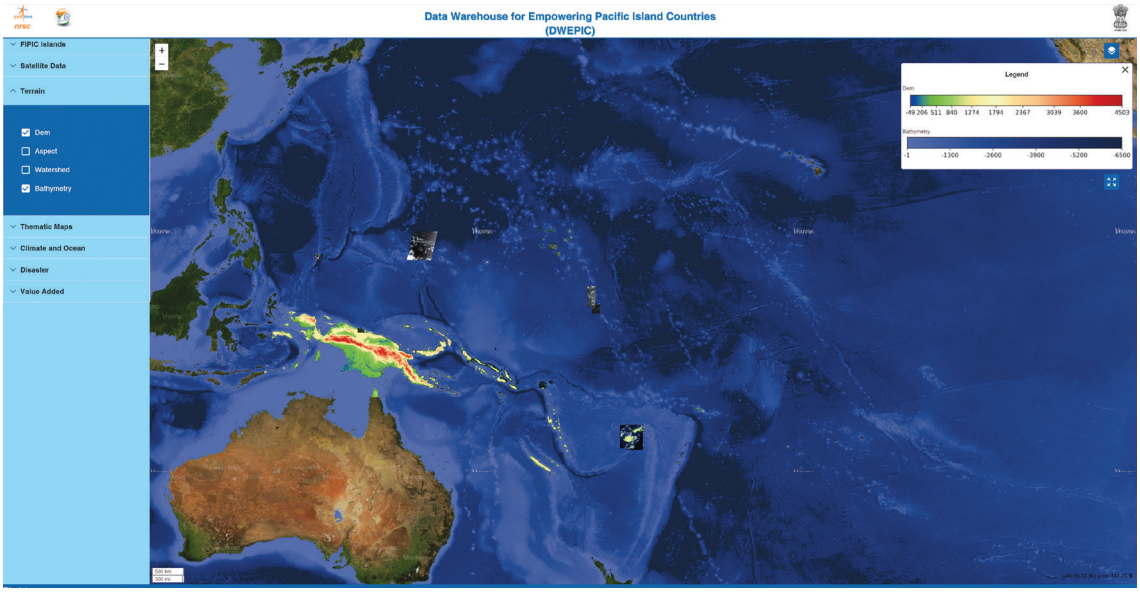
Generation of Digital elevation data for flood inundation modelling: Airborne LiDAR and Digital Camera data acquisition in Ganga basin in UP state is completed for 12350 sq.km out of 15044 sq.km for flood inundation modeling.

Remote sensing enabled Online Chemical Emergency Response System (ROCERS): An online real time monitoring and Decision Support System for chemical emergencies is developed for State Government of Kerala with a collaborative participation among NRSC, IGCAR and FAB, Kerala. The system is enabled with real time sensors monitoring hazardous chemicals like Ammonia, Chlorine and LPG around Major Hazardous industrial clusters in Kerala. ROCERS is enabled with Integration of weather based simulation and forecast systems along with geospatial decision support systems using state of the art Angular frameworks along with leaflets and host of open source libraries and real time communication protocols.

International Charter/Sentinel Asia: Under the International Charter - Space and Major Disasters, ISRO supported 29 events across 24 countries and supplied 170 products during 2023. Also, 31 requests were serviced under Sentinel-Asia resulting in 101 products in cooperation for emergencies. During the period, 100% requests were serviced for International Charter and Sentinel Asia.

2.1 Earth Observation, Data Processing, and Applications

DWEPIC: Geospatial capabilities available with Bhuvan and MOSDAC has been customised for 14 Pacific islands under Forum for India-Pacific Islands Cooperation (FIPIC), named DWEPIC (Data Warehouse for Empowering Pacific Island Countries), with provisions for satellite data visualization, thematic information, disaster management support, etc.



DWEPIC GIS Portal

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 communication satellites are owned and operated by M/s NewSpace India Limited, a CPSE under the Department of Space. All 18 satellites together provide 317 operational bent-pipe transponders and 25 Gbps high throughput satellite (HTS) capacity. These satellites support services like television broadcasting, DTH television, telecommunication, VSATs, radio networking, strategic communication and societal applications. The prominent users of the transponders are Government and 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 the support for 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.

In order to meet additional transponder requirements from various user sectors, about 70 transponders in Ku-Band and HTS capacity of 1.6 GHz are leased from international satellite operators, on a back-to-back arrangement with users and satellite operators. In addition, about 40 transponders in C-band, are directly leased by the broadcasters for TV uplinking. Thus, satellite communication is playing a major role in the socio-economic development of the country.

High Throughput Satellites

Broadband requirements continue to increase driven by the growth of 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 recuse 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. Using these satellites, more than 6850 user terminals are deployed across the country.

Television

Communication Satellites have been a major catalyst for the expansion of television

2.2 Space Applications

coverage over India through various broad casters including Doordarshan. DOS/ISRO has made available the required transponder capacity has been made available through Indian and foreign satellites to cater to the needs of the television sector.

Doordarshan is presently operating 35 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 40 C-band Earth Stations for program contribution and 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. The satellite communication has played a key role in capturing live news and events through DSNG services.

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 502 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.

Presently, the licensed SATCOM network in the country consists of more than 80 Teleports, 75 VSAT Hubs, and 2.80 Lakh VSAT terminals of different sizes and capabilities and they are operating in satellite networks of BSNL, Government users, Closed user groups, commercial users, and broadcasters and are being utilized for telecommunications and broadcasting applications. 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 utilized for the benefit of society. Telemedicine technology utilizes Information & Communications Technology (ICT) based system consisting of customized Telemedicine software integrated with computer hardware and medical diagnostic instruments connected to the commercial Very Small Aperture Terminal (VSAT). Telemedicine enables patients 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.

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. as well as in glacier regions like Siachin. At present, around 179 Telemedicine nodes are operational. Out of these, around 80 Telemedicine nodes are located in high-altitude regions.

ISRO TM network was used by J&K Health Department for providing Telemedicine services during Amarnath Yatra 2023. One node was installed at the Baltal base camp and another node was installed at Panchtarani, en route to Holy Cave Shri Amarnathji. Also three (03) new nodes were established for Border Roads Organisation (BRO).

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 2023, seven CMEs have been conducted.

2.2 Space Applications

Tele-education

Satellite communication plays an important role in providing Tele-Education (TE) programs to students in remote areas using live and recorded broadcasts. It supplements curriculum-based education for primary & secondary schools and undergraduate as well as postgraduate students. It also provides teacher's training as and when required. The Tele-Education networks are functional in Karnataka, Rajasthan, Manipur, Mizoram, Andhra Pradesh, Chhattisgarh, Orissa, Uttarakhand, Jharkhand, Assam, Sikkim, Jammu, Kashmir, Kerala, West Bengal and Andaman& Nicobar.

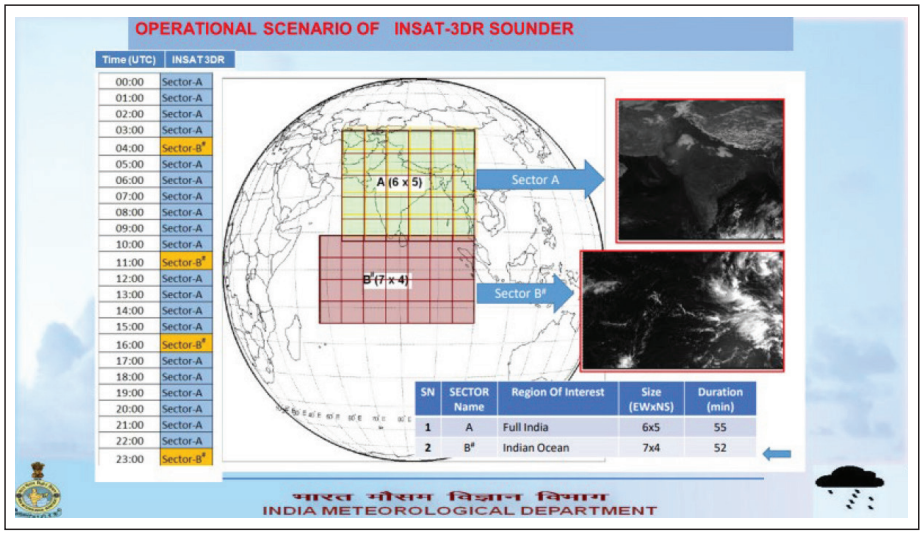
Satellite capacity and technical support were provided to BISAG-N for establishing 200 educational channels under the PM-eVidya Program.

Satellite Meteorology

Satellites provide the essential inputs for the meteorological applications. INSAT-3D and INSAT-3DR (Imager, Sounder, DRT) satellites carrying meteorological payloads are supporting weather forecasting services. The data received from the satellites is processed and disseminated by the INSAT Meteorological Data Processing System (IMDPS) at the India Meteorological Department (IMD). The system is capable to receive 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 (24/7 bases).

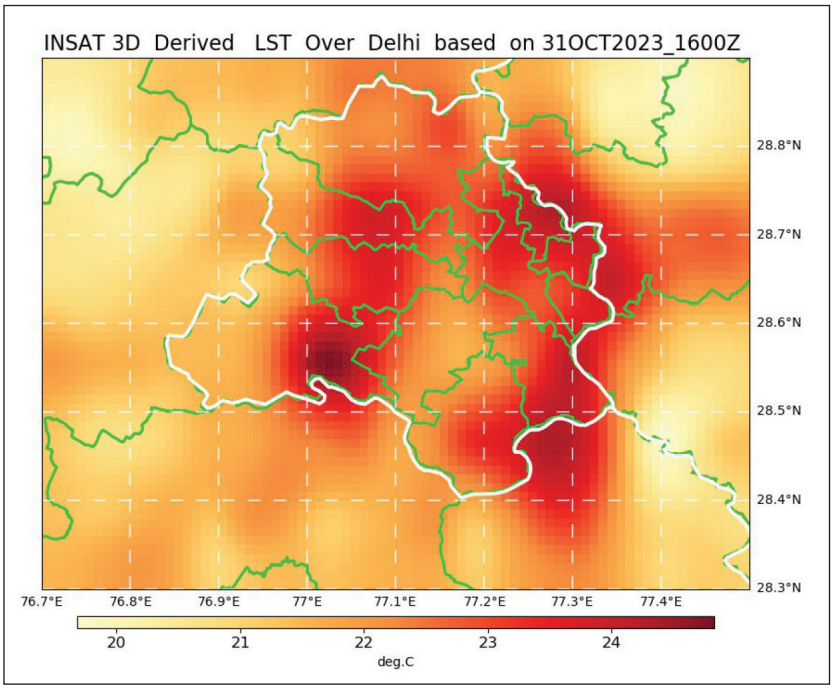
The Imager payload of INSAT-3D and INSAT-3DR is being used in the staggered mode so that a 15-minute temporal resolution is achieved.

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 (04, 11, 16 & 23 UTC) on an hourly basis.



Scan strategy of INSAT-3DR sounder

Satellite-based Land Surface temperature product for Delhi-NCR is generated in a pilot mode. The region-specific land surface temperature values are plotted for an improved understanding of the urban hotspots over the city.



New product (LST) generated from MMDRPS system

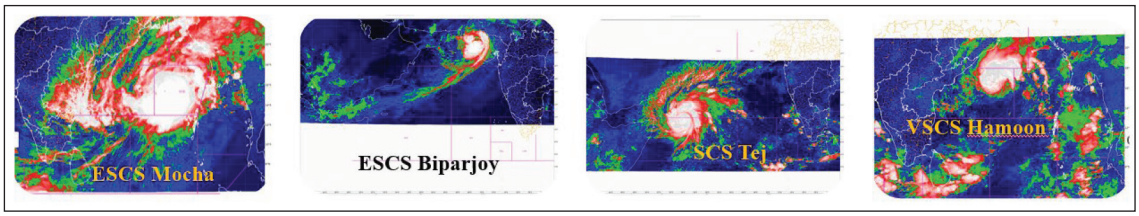
During the year 2023, tropical cyclones Mocha, Biparjoy, Tej, and Hamoon were monitored with INSAT 3D and 3DR. Advanced Dvorak Technique (ADT) software customized for INSAT-3D was implemented to determine the intensity of Tropical Cyclones. During extreme weather events, INSAT 3DR imager was used for Rapid Scanning. Rapid scans were conducted during major cyclonic events like Mocha, Biparjoy, Tej, Hamoon etc as per the schedule given below.

Major Cyclonic Events and Rapid Scans

S.No	Name of cyclone	Duration	Total Number of Rapid Scans
1.	ESCS-Mocha	May 09-15, 2023	1493
2.	ESCS- Biparjoy	June 06-19, 2023	2880
3.	SCS Tej	October 20-24, 2023	1152
4.	VSCS Hamoon	October 21-25, 2023	1440

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

2.2 Space Applications



INSAT-3DR Imager rapid scan during cyclonic storms.

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 34 years.

INSAT-3D (82 Deg East), INSAT-3DR (74 Deg 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 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 the 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 the 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) was established during the year and its evaluation is under progress.

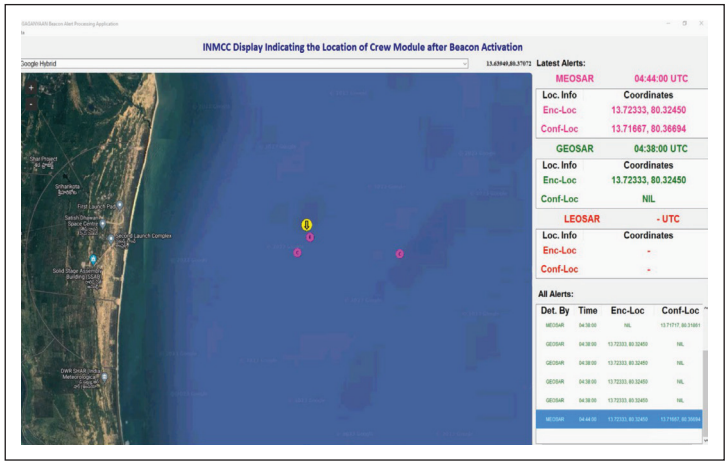
Indian Coast Guard conducted a 24th beacon exercise was carried out involving various stakeholders and international participants from August 10-12, 2022, wherein INMCC detected and relayed a mock-up distress alert. Seminars and Workshops on SAR-related activities and operations were conducted for AAI,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

INMCC received the award 2022-23 for the Ashore unit from the Chairman, NMSAR Board (Director General of Coast Guard) because of the contribution towards the SAR community. This is one of its kinds in the past 30 years.

INMCC received the award 2022-23 for the Ashore unit from the Chairman, NMSAR Board

INMCC supported the TV-D1 mission for the Gaganyaan Mission during October 2023. Touchdown location was provided to NAVY as displayed live in SHAR. Indian GEOLUT and Global MEOLUT provided the instantaneous locations during the mission in addition to Indian MEOLUT.

From January to December 2023, the Indian Mission Control Center (INMCC) provided search and rescue support to 9 distress incidents in the Indian service area and contributed to saving 22 human lives. During this period, 1218 new radio beacons were added to the Indian database. To date, there are 1117 registered users and the total number registered beacons are 20254 in our database. INMCC



Crew module Beacon location Live Display

upgraded the National Beacon Registration Database to accommodate registration of Return Link Service (RLS) beacons - ELT (DT) and second Generation beacons.

MEOSAR project

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

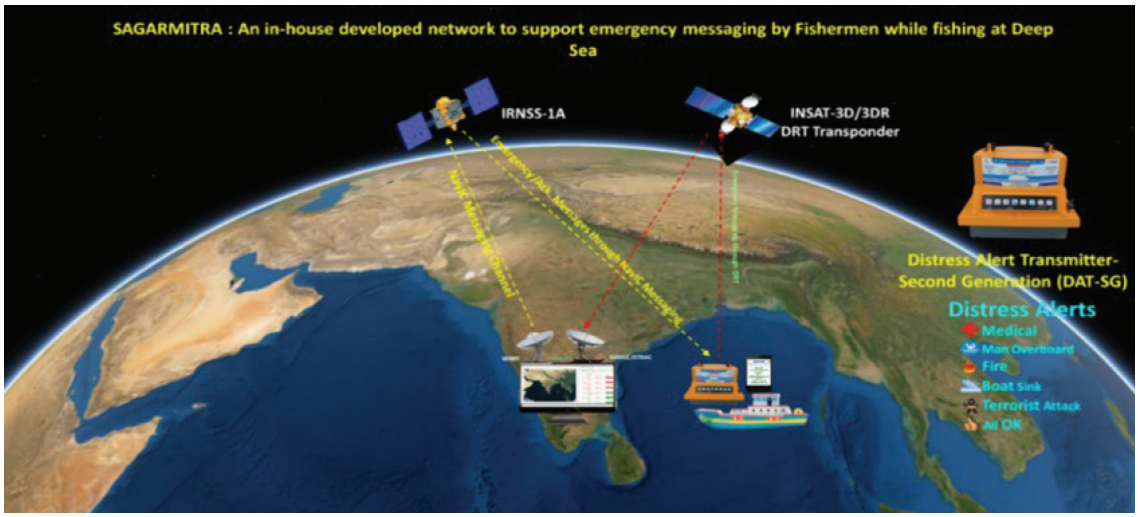
ISTRAC has planned to facilitate the SAR programme by augmenting it with a MEOSAR satellite receiving ground segments from GNSS satellite constellations (GPS, GLONASS, and Galileo). ISTRAC has installed an indigenously developed 6+1 antennae MEOSAR ground segment, which includes the design and development of the following sub-systems. T&E of the overall system is 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. 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 which 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 had developed a 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 and 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

South Asia Satellite

South Asia Satellite (SAS) was launched on May 05, 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 two transponders in Bhutan for the utilization of SAS and operation. The local team has been trained to handle operations and maintenance of the network. The network is being used for uplinking two TV channels and 4 Radio channels of Bhutan, Internet connectivity, connecting the Disaster Management Centers, and critical telecom links.

Bangladesh has established a dedicated network with a hub in Dhaka to connect more than 100 schools, using two transponders on SAS.

The Maldives is using one transponder on the south Asia satellite for satcom-based connectivity for islands with support from the common Hub at DES, New Delhi.

A project proposal for the establishment of a dedicated satcom network with a hub and 300 terminals, in Nepal is under consideration.

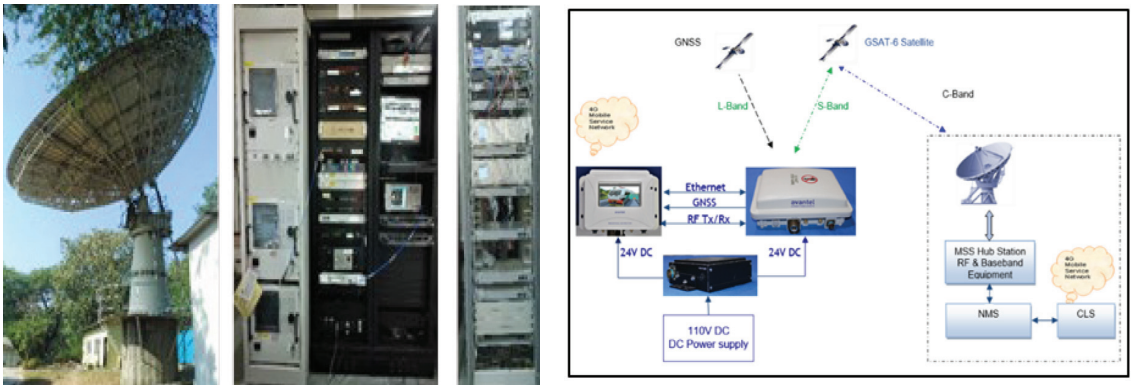
Mobile Satellite Services (MSS)

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.

2.2 Space Applications

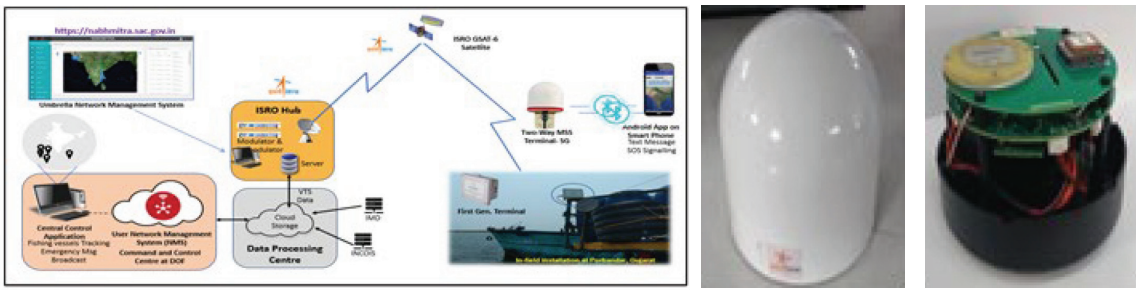
6.3m and 11.5m C-band Earth stations at Ahmedabad & Delhi with necessary baseband sub-systems have been established to provide uninterrupted services & demonstration.

Using MSS service an indigenous solution has been developed and implemented for tracking the Trains in real-time namely "Real-time Train Information System (RTIS)". This enables the enhancement of safety and operations of the Train services particularly in strategic segments. This 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, 8000 trains were covered with RTIS with the capability to track the position of locomotives in real-time.



RTIS Network

ISRO has developed SATCOM terminals for tracking sub-20m fishing vessels/ boats that 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, the Department of Fisheries has undertaken a rollout of this solution for one lakh fishing vessels through M/s NSIL.



Fishing Vessel Tracking Network

2.3 Navigation Systems

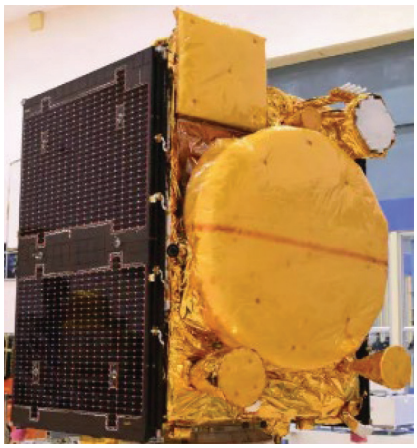
Navigation with Indian Constellation (NavIC) is India's independent regional navigation satellite system catering to a coverage area of India and 1500 km beyond the Indian landmass. ISRO has established the space and ground infrastructure. ISRO is making continuous efforts to enable civilian sectors like land transportation, aviation, maritime, mapping, surveying, geodesy, timing, telecommunications, etc., to utilize 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 2023 have been:

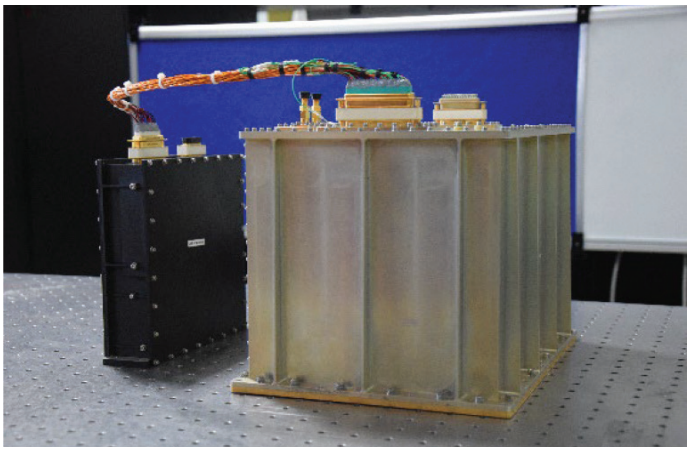
1. NavIC base layer constellation

NVS-01 satellite was realised with continuity of legacy service and with new features viz. optimised long code, civilian L1 signal, and indigenous atomic clock. The satellite was launched onboard GSLV-F12 on May 29, 2023. In-orbit tests were conducted during June 2023 and the satellite was cleared for navigation operations in the first week of July 2023. Indigenous rubidium atomic frequency standard (iRAFS) was tested in orbit and has been selected as the primary clock.

Signal-in-space interface control document (SIS ICD) of the civilian L1 signal was published on the ISRO website to facilitate implementation in the user segment.



NVS-01 satellite



Indigenous rubidium atomic frequency standard (iRAFS) own in NVS-01

With the inclusion of NVS-01, the NavIC base layer now consists of five satellites (IRNSS-1B, 1C, 1F, 1I and NVS-01) for operational service.

2. Aadhaar enrolment devices

Unique Identification Authority of India (UIDAI) has initiated the process for procurement of NavIC-enabled receiver for induction into Aadhaar enrolment centres. A technical committee, including experts from ISRO, is in the process of finalising technology and encryption algorithms for the integration of wireless NavIC-enabled receivers.

3. National disaster warning system

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 integrated in CAP by C-DoT. The service has been rolled out to the public via Sachet mobile app.

4. Consumer devices

There are more than 50 mobile handsets in India with NavIC capability. These include handsets manufactured by the reputed OEMs and also those that are made in India. 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, NVS-01 and subsequent NavIC satellites will have civilian signals in the L1 band in addition to legacy signals in the L5 and S-bands.

5. Indigenous multi-GNSS chip

Indian industry m/s Accord has developed NavIC-based multi-GNSS SPS chip under a MeitY contract. ISRO has contributed to the technical evaluation process. The chip has completed technical evaluation and has been cleared for production.

6. Indigenous reference receiver

Indigenously developed tri-band (L1, L5, and S-band) reference receiver has been realised and inducted into the NavIC ground segment.

Indigenous tri-band reference receiver in NavIC ground segment

7. Industry standards

a. Maritime equipment

International Electrotechnical Commission (IEC) develops standards for GNSS-based shipborne receiver equipment. IEC has released IEC 61108-6 standard for NavIC-based maritime receiver equipment. ISRO has contributed to formulation of the standard, with the support of the Bureau of Indian Standards (BIS). Another standard IEC 61108-7 for augmentation systems, including GAGAN, is being reviewed by the member states.

b. Unmanned aerial vehicles

BIS has released the national standard IS 18381:2023 for general-purpose drones. NavIC is included in the specification for a drone navigation system. ISRO has actively participated in the discussions and provided relevant technical inputs.

2.4 Space Science Exploration and Research

Space Science exploration and research, as well as capacity building in the country, have been of utmost importance in the Indian space programme. The activities are divided into a few verticals, viz. (i) **Heliosphere, Astronomy & Astrophysics, (ii) Solar System Bodies, (iii) Space Weather, and (iv) Atmospheric Science.** The vertical **Heliosphere, Astronomy & Astrophysics** encompasses Solar astronomy, Earth-like exoplanets, and multi-wavelength & multi-messenger Astronomy. The vertical Solar System Bodies cover the sub-surface, surface, atmosphere, composition & dynamics, electric and magnetic fields of the Solar System Bodies (planets, natural satellites, as well as the small bodies of the solar system). The vertical **Space Weather** is includes the facets of the Sun-Earth connection covering the aspects of Upper atmosphere-Ionosphere-Thermosphere-Magnetosphere-Sun coupling. The vertical **Atmospheric science** addresses the aspects of Troposphere-to-Mesosphere processes & Coupling; Aerosols, Trace Gases, Volatile Organic Compounds (VOC); Water Vapour- Clouds-Precipitation processes, Line by Line Radiative Transfer Codes aimed towards the development of sensors for various trace gas concentration measurement from satellites, Weather - Climate linkages. These verticals connect the various atmospheric processes with the space weather and strengthen areas like trace (greenhouse) gas concentration monitoring, hydrological cycle, etc., towards a comprehensive understanding of climate change and associated risks. Some of these may be linked to the development of suitable sensors for planetary missions as well.

The activities on space science research and exploration are carried out at several centres and laboratories of ISRO/DOS. The activities include modelling, simulation, space and ground-based observations, analysis of the observations, laboratory analysis of the meteoroids, as well as space and ground-based instrumentation. International cooperation also plays a vital role in the Indian space exploration programme. The major activities carried out under space science exploration and research during 2023-24 are summarised below.

Chandrayaan-3 Science Planning, Landing and Payload Operations

- After the successful soft-landing of the Ch-3 lander-rover module on August 23, 2023, at 69.3 deg S and 32.3 deg E, the science payloads were deployed and operated, as per the science plan document released by ISRO HQ. The Chandrayaan-3 Science Working Group (Ch3-SWG) has taken periodic reviews of the operations, data quality, and initial results, which facilitated making online decisions on the payload operations.

- Preliminary science results from Chandrayaan-3 include:
  - First-ever measurements of near-surface lunar plasma environment, indicating that the plasma near the surface is relatively sparse.
  - First-ever probing of a few cm of lunar regolith is done which shows a strong vertical gradient of temperature.
  - Capture of the vibration signatures on the lunar surface.
  - Detection of constituent elements of the lunar regolith.
  - APXS spectra showed the presence of all major elements and several minor elements around the landing site.

Other Ongoing Space Science Missions

Aditya-L1 mission

- On September 02, 2023, Aditya-L1, the first Indian solar mission was launched on-board PSLV-C57 from Sriharikota. Aditya-L1 was inserted into the designated halo orbit around the Sun-Earth L1 point on January 06, 2024. Satellite is healthy.
- The Supra Thermal & Energetic Particle Spectrometer (STEPS) instrument, on Aditya Solar Wind Particle EXperiment (ASPEX) payload was switched ON when the S/C is above 50,000 from Earth. It collected data on the variation of energetic particle environment within Earth's magnetosphere.

Chandrayaan-2 Mission

- Chandrayaan-2 Orbiter completed more than 4 years around the Moon. The spacecraft's health is normal. All the payloads are operational and healthy.
- A total of ~20 TB of data have been released so far in the public domain, and there are 4275 users registered on the ISSDC website.
- So far, the major science highlights from Chandrayaan-2 are:
  - Unambiguous detection of Lunar hydration absorption feature around 3 μm at all latitudes and surface types.
  - Characterisation of noble gas dynamics in the sunlit lunar exosphere by global mapping of Argon-40 that originate from the lunar interior.
  - Full polarimetric measurements to image permanently shadowed regions and to identify water-ice deposits in the polar regions.
  - Mapping the abundance of sodium on the Moon for the very first time.
  - Detection of large number of microflares occurring outside the Sun's active region which may provide clues to the coronal heating problem.

2.4 Space Science Exploration and Research

AstroSat mission

- An announcement of opportunity soliciting proposals for AstroSat data under AO13 is released. Observations under AO23 started in October 2023.
- Ongoing: 28 funded projects under AstroSat data utilization.
- AstroSat has resulted in several interesting results which led to more close to 70 publications in 2023.
- AstroSat data has contributed to around 6 PhD theses in 2023.
- An expert-level workshop over one week duration was organized to train AstroSat users in interpretation of the results of data analysis. Problems were defined and trained till publication draft preparation.

XPoSat mission

- XPoSat Pre-Shipment Review was completed on August 10, 2023, after completion of all the major tests and reviews, the Mission Operation Review was held on November 10, 2023.
- Two days of extensive science working group meetings has been conducted in ISRO HQ during October 14-15, 2023.
- XPoSat was launched on January 01, 2024.

Participants during XPoSat user meet in ISRO HQ

Space Science Missions – In Proposal / Study Phase

Venus Mission Proposal

- Regular theme-based discussion meetings on the Venusian surface, sub-surface, atmosphere, and ionosphere, as well as Sun-Venus interaction with the PAN-India scientific community have been conducted as a step towards enhancing the science

community and to bring out areas which are needed to be focused on with regard to capacity building, facility augmentation and interlinking of payload science towards core science goals of the proposed Venus Orbiter Mission.

- Scientists are working towards bringing out the outstanding science issues of the Planet Venus, and recommend an action plan.

DISHA (Aeronomy) mission Proposal

- Discussions with researchers from several Indian academic institutes (beyond ISRO/DOS) on the outstanding problems in ionosphere-thermosphere research have taken place. There was a unanimous opinion from researchers that data from the proposed DISHA mission would help in the development of reference ionospheric models, understanding of spatio-temporal extent of latitudinal and longitudinal variability and arriving at remedial actions to improve GNSS-based services.
- ISRO has been conducting internal reviews on the readiness of the DISHA H & L payloads for their realisation within a short turn-around time.

LuPEX mission proposal

- Technical Interface meeting with the JAXA team was held on April 19, 2023 at ICTS, Bengaluru.
- Phase-A study is concluded and a joint report has been prepared and submitted.
- Lander configuration is matured and it is under review process.
- ISRO and JAXA team members had a face-to-face Technical Interface Meeting (TIM) on the proposed Lupex mission at the International Centre for Theoretical Sciences (ICTS),

Participants during ISRO-JAXA Technical Interface Meeting on LuPex

Bengaluru, on April 19, 2023. The ISRO team was led by Shri Ravichandra Babu, Lupex study team lead, URSC, ISRO, while the JAXA team was led by Mr. Dai Asoh, project manager, Lupex, JAXA. Dr. Tirtha Pratim Das, Director, SPO, ISRO HQ coordinated the discussions. A few members from Mitsubishi Heavy Industries (MHI), Japan also attended the meeting.

Seed-funded projects on Astronomy

- A few projects short-listed by Apex Science Board, ISRO are funded for pre-developmental activities.

Mars Lander Mission

- A task team has been constituted under the study team to identify the possible landing sites for the Mars lander Mission. Various Sub-task teams have also been formed to bring out science observation requirements, atmospheric density models and engineering constraints.
- Preliminary observations of the sub-task teams were presented to the task team.

National Expert Meet for Chandrayaan-3 and Aditya-L1

On May 19, 2023, ISRO organized a one-day appraisal of the national academia and research institutes on the forthcoming space science missions Chandrayaan-3 and Aditya-L1, in the premises of the ISRO Headquarters, Bengaluru. The meeting was attended by more than three hundred scientists, academicians and engineers representing 20 academic and research institutes of the country, apart from a set of former and serving scientists from the centres of ISRO / Department of Space, in offline and online modes.

Participants during National Expert Meet for Chandrayaan-3 and Aditya-L1 at ISRO Headquarters

International Collaboration on Space Science Exploration

International Cooperation activities have been conducted through the mechanisms of ISRO – NASA Planetary Science Working Group, ISRO-ASI Heliophysics Working Group, ISRO-NOAA Heliophysics Co-operation, International Space Exploration Coordination Group (ISECG), International Mars Exploration Working group, to name a few. There have also been regular discussions with space agencies like NASA, ESA, JAXA, CNES, ASI, NASRDA on various aspects of cooperation in space research and exploration. ISRO is also a part of the COSPAR Task group for a constellation of Small satellites.

Space Science Promotion and Community Building

ISRO has contributed towards community building in the country in the realm of space sciences, as well as worked towards space science promotion, through a multi-pronged approach. In order to effectively engage academia, and build human capacity in space sciences ISRO took several approaches, which include (i) Mission-specific workshops and user meets, (ii) Space Science Exploration Workshop with academia, (iii) Offering online courses to the various facets of space science and technology, (iv) Awareness lectures for students and faculty members in academia, and (v) Engaging student community in innovation for space science & technology. A brief description of the activities is presented in this section.

Mission-Specific Workshops and User Meets

Chandrayaan-3 Data Analysis Workshop

A two-day data analysis and training workshop was organised during March 28-29, 2023, at the IDSN campus, Byalalu. The workshop was attended by 50 participants which included 24 faculty members and senior students from Universities and Institutes who would use the lunar data.

2.4 Space Science Exploration and Research

Participants during Chandrayaan-3 science data user meeting at Byalalu

Aditya-L1 Solar Science Workshops

- Several outreach events and lectures were conducted in different parts of the country. Outreach materials and videos were made available on ISRO website.
- Three Aditya-L1 workshops with in-person hands-on (archival) data training were completed in different parts of the country under the Aditya-L1 support cell.

Chandrayaan-2 Announcement-of-Opportunity (AO) Projects with Academia

- 30 projects from various academia and universities across the country are funded through the Ch-2 AO programme.

XPoSat User Meet

- XPoSat User Meet was organized on May 25, 2023, in ISRO HQ. Space Science Workshops with Academia. Around 120 users benefited from the lectures and demonstrations on data analysis.
- The next XPoSat user meet was held during December 18-19, 2023, in ISRO HQ.

Space Science Exploration Workshop with Academia

- A two-day space science and exploration workshop was conducted by ISRO, in association with the Vidnan Parishad Goa. About 150 post-graduate students in and around the state of Goa were befitted by the lectures and the interaction sessions with the scientists.

- A single-day workshop on space science and exploration was conducted by ISRO, in association with the Soundarya Institute, Bengaluru, targeting high school and undergraduate students. Around 500 students from several schools and colleges benefited from the lectures and interactions with the scientists.

Online Course: ISRO-START Programme for Space Sciences

- Space science and Technology AwaReness Training (START) programme, a new initiative of ISRO, was conducted online mode during July 20-August 07, 2023. The theme of this event was "Overview of Space Science and Technology". This newly initiated programme mainly targets post-graduate and final-year under-graduate students of physical sciences and technology studying in Indian educational institutes/ Universities/Colleges. The first edition of the START programme has benefitted more than 35,000 participants.
- Twenty-three lectures were delivered by experts on different facets of space science and technology like Geosphere-Biosphere-Atmosphere, Solar System Exploration, Space Mission Design and Observations, Astronomy, Astrophysics, Cosmology, as well as technological aspects like accessing space, space instrumentation, to name a few. In addition to these, there were lectures on the Indian space exploration programme and research opportunities in the fields of space science and technology.

Space science awareness lectures delivered

A total of 40 space science awareness lectures have been delivered in different forums which have benefitted students, faculty members, as well as space science enthusiasts.

Engaging Student Community: Problem Statement and Mentorship in Inter-IIT Tech Feast

ISRO has provided a problem statement on generating super-resolution lunar topography generation in the inter-IIT tech feast. The students developed AI/ML models to generate super-resolution images from TMC-2 (Chandrayaan-2) by using the high-resolution images taken by OHRC (Chandrayaan-2) as training set data. The students have successfully generated a high-resolution map for a given region of the Moon using their AI/ML model.

2.4 Space Science Exploration and Research

Strategy for way forward

Vision-2047: Roadmap Preparation for Space Science Exploration

A roadmap for space science exploration is prepared during the DOS *Chintan Shivir*, organised by ISRO/DOS in line with the Vision-2047 of the Government of India. A report is prepared in this connection, which, apart from presenting the roadmap, covers the global scenario, status of the research and exploration in India, gap areas, and recommendations on action plan, first to catch up with the global evolution, and then to eventually excel, in all the major verticals of space science exploration. The report also recommends the Departmental / National level facilities required for the progress of space and planetary exploration.

2.5 Space Transportation Systems

The benefits that humanity derives from space and its associated applications support the continued exploration and development of space technologies. Space technology is a vital tool as it furnishes direct and tangible benefits to people on Earth. Assured access to space is a critical goal for the nation's growth in space. 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 Geosynchronous Satellite Launch Vehicle – Mark III (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 realized to transport humans safely to LEO. In line with the Indian Space Policy - 2023, industries will play a major role in the operations of existing launch vehicles and in the development of future technologies. The development of technologies for heavy lift launchers and reusable launch vehicles to provide a cost-effective space transportation system with heavy lift capability is being taken up by ISRO with the support of industries and academia. Towards this, technologies including semi-cryogenic engines, LOX-Methane engines, clustering of liquid engines, Electric propulsion, Vertical Take-off and Vertical Landing, Vertical Take-Off, Re-entry and autonomous Runway Landing, etc. are currently being developed.

Major Events

- **Polar Satellite Launch Vehicle (PSLV):** The Polar Satellite Launch Vehicle (PSLV) completed its 59th launch during the 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.

2.5 Space Transportation Systems

- PSLV-C55/ TeLEOS-2: PSLV-C55 was a dedicated commercial mission by M/s NSIL for a customer from Singapore. In this mission, TeLEOS-2, a Synthetic Aperture Radar satellite and Lumelite-4, a co-passenger Technology Demonstration nano-satellite were successfully injected into a low inclination orbit of 586 km altitude on April 22, 2023, from Satish Dhawan Space Centre, Sriharikota. The mission also hosted 7 payloads from Indian Space startups and Academia on the PSLV Orbital Experimental Module (POEM-2) where the spent PS4 stage of the launch vehicle was utilized as an orbital platform to carry out scientific experiments through non-separating payloads.

PSLV-C55 / TeLEOS-2 Mission

- PSLV-C56/ DS-SAR: PSLV-C56 was also a dedicated commercial Mission by M/s NSIL for a satellite from Singapore. PSLV-C56 successfully launched and injected the DS-SAR satellite along with six other co-passenger satellites from Singapore (ARCADE, VELOX-AM, SCOOB-II, ORB-12 STRIDER, Galassia-2, NuLIoN) into an orbit of 535 km altitude with 5° inclination on July 30, 2023, from the First launch pad at Satish Dhawan Space Centre, SHAR, Sriharikota. This was the 58th mission of PSLV and the 17th mission using the PSLV-Core Alone variant. In this mission, after completion of the primary mission PS4 stage was de-orbited to a 300 km circular using left-out propellants to reduce its orbital life.

PSLV-C56 / DS-SAR Mission

- PSLV-C57/ ADITYA-L1: PSLV-C57 successfully launched India's first space-based solar observatory class satellite i.e., Aditya-L1 into an elliptical orbit of 235x19500 km around the Earth after a flight duration of 63 minutes and 20 seconds on September 02, 2023 from Second Launch Pad, Satish Dhawan Space Centre SHAR.

PSLV-C57 / Aditya-L1 Mission

PSLV-C57 was the 59th flight of PSLV and the 25th mission in PSLV-XL configuration. The spacecraft performed orbital maneuvers using its Liquid Apogee Motor (LAM) and is currently cruising towards the Sun-Earth Lagrange point L1 (1.5 million km from Earth). Aditya-L1 carries payloads developed by national research laboratories including the Indian Institute of Astrophysics (IIA), Bengaluru and Inter-University Centre for Astronomy & Astrophysics (IUCAA), Pune along with seven scientific payloads of ISRO, for a systematic study of the Sun.

- PSLV-C58/ XPoSat: PSLV-C58 vehicle in its 60th flight, successfully launched India's first dedicated polarimetry mission i.e., XPoSAT spacecraft on January 01, 2024, into the intended orbit of 650 km with a 6-degress inclination, to carry out research in space-based polarisation measurements of X-ray emission from celestial sources. PSLV-C58 is the 60th flight of PSLV and the fourth mission using the PSLV-DL configuration. The spacecraft carries two payloads namely POLIX (Polarimeter Instrument in X-rays) realized by Raman Research Institute and XSPECT (X-ray Spectroscopy and Timing) realized by ISRO. Subsequently, the upper stage performed two orbit change maneuvers to bring down the orbit to 350 km altitude and started functioning as PSLV Orbital Experimental Module (POEM-3) for nine scientific/technology demonstration payloads including six payloads from Indian startups & academia enabled through IN-SPACe, and three technology demonstration payloads from Physical Research Laboratory and ISRO. ISRO tested a 100 W class Fuel Cell-based Power System (FCPS) and during the short-duration test, 100W power was generated from Hydrogen and Oxygen gases stored onboard in high-pressure vessels. ISRO also qualified 10 Ah Silicon–Graphite anode-based high energy density Li-ion cells as a low-weight and low-cost alternative to the present cells being used. The 4th stage of the PSLV-C58 vehicle, which functioned as PSLV Orbital Experimental Module (POEM-3) after completing the primary mission launched on January 01, 2024, successfully re-entered the Earth's atmosphere on March 21, 2024, thereby leaving zero debris in orbit from the PSLV-C58/XPoSat mission.

PSLV-C58 / XPoSat Mission

- **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 spacecraft into Geosynchronous Transfer Orbit (GTO).

2.5 Space Transportation Systems

- GSLV-F12/ NVS-01: GSLV-F12 successfully deployed the NVS-01 navigation satellite, weighing about 2232 kg, into a Geosynchronous Transfer Orbit on May 29, 2023 from Second Launch Pad at Satish Dhawan Space Centre, Sriharikota. GSLV-F12 was the 15th flight of GSLV, the 9th flight with Indigenous Cryogenic stage and the second mission with Ø4m Ogive PLF. NVS-01 is the first of the second-generation series of Indian navigation satellites. This series will ensure the continuity of legacy NavIC services and provide new services in the L1 band.

GSLV F12 / NVS-01 Mission

- GSLV-F14/ INSAT-3DS: GSLV-F14 successfully accomplished the launch of the INSAT-3DS satellite on February 17, 2024, at 17:30 Hrs. IST from Second Launch Pad at Satish Dhawan Space Centre, Sriharikota. In its 16th mission, the GSLV deployed the INSAT-3DS meteorological satellite into the Geosynchronous Transfer Orbit (GTO) and subsequent orbit-raising maneuvers ensured that the satellite was positioned in a Geo-stationary orbit. INSAT-3DS Satellite is a follow-on mission of Third Generation Meteorological Satellite from Geostationary Orbit. It is designed for enhanced meteorological observations and monitoring of land and ocean surfaces for weather forecasting and disaster warning.

GSLV F14 / INSAT-3DS Mission

- **Geo Synchronous Satellite Launch Vehicle MKIII (LVM3):** LVM3 is a three-stage launch vehicle with two solid strap-on motors (S200), one liquid core stage (L110) and a cryogenic upper stage (C25).
  - LVM3-M3/ OneWeb India-2: LVM3-M3 mission was the second dedicated commercial mission by M/s NSIL for M/s Network Access Associates Ltd., United Kingdom. This was a repeat mission of LVM3-M2 to deploy the second batch of 36

LVM3 M3 / OneWeb India-2 Mission

OneWeb satellites for their LEO constellation. LVM3-M3 lifted off from the Second launch pad at Satish Dhawan Space Centre, Sriharikota with a total payload mass of 5805 kg and deployed the satellites into an orbit of 450 km altitude on March 26, 2023.

- LVM3-M4/ Chandrayaan-3: LVM3-M4 successfully launched India's prestigious third lunar exploration mission, Chandrayaan-3. The spacecraft, weighing 3895 kg was launched into an orbit of 170 x 36500 km on July 14, 2023, from the Second launch pad at Satish Dhawan Space Centre, Sriharikota. The launch met all the mission requirements and precisely placed the spacecraft into the desired earth orbit from where the Propulsion Module of Chandrayaan-3 carried the Lander & Rover to the Moon. This was the 4th operational mission of the LVM3 vehicle.

LVM3 M4 / Chandrayaan-3 Mission

- **Small Satellite Launch Vehicle (SSLV):** SSLV is an all-solid three-stage vehicle capable of launching 500 kg class satellites into a 500 km planar orbit.
  - SSLV D2/ EOS-07: The second developmental flight of the Small Satellite Launch Vehicle, SSLV-D2, successfully deployed EOS-07, an earth observation satellite along with two co-passenger satellites, Janus-1 & AzadiSAT-2 into a 450 km circular orbit on February 10, 2023, from Satish Dhawan Space Centre, Sriharikota. The anomaly observed in the previous SSLV-D1 mission was thoroughly investigated and design changes were implemented. With this mission, all the launch vehicle systems of SSLV have been validated successfully and demonstrated the launch-on-demand capability through a short launch campaign duration of 5 days.

SSLV-D2 / EOS-07 Mission

  - Third developmental mission of SSLV i.e., SSLV-D3 is planned during Q3 2024 to launch an Earth Observation Satellite (EOS) from ISRO. Further missions of SSLV during the operational phase will be realized through M/s NSIL and industries.
- **Reusable Launch Vehicle (RLV):** The objective of the current RLV programme is to

demonstrate critical technologies required for developing a wing body reentry vehicle similar to that of an aircraft.

- **RLV-LEX Mission:** ISRO successfully conducted the Autonomous Landing Experiment of the Reusable Launch Vehicle (RLV LEX) at the Aeronautical Test Range (ATR) of DRDO on April 02, 2023. An Indian Air Force Helicopter lifted off with the RLV and after a combined flight of approximately 25 minutes, RLV was released at an altitude of 4.5km above the mean sea level and a downrange of approximately 4.5km from the runway. After separation, RLV had a controlled descent by navigating autonomously to successfully land on the runway within 60 seconds. With this experiment critical technologies such as autonomous navigation, guidance, & control systems, and landing gears for runway landing were successfully demonstrated. Experimental data from this flight will pave the way for orbital flight and autonomous re-entry mission of a winged RLV.

RLV-LEX Mission

- RLV LEX- 02 Mission: The second autonomous runway landing experiment of the Reusable Launch Vehicle (RLV LEX-02) was conducted successfully on March 22, 2024, at the Aeronautical Test Range (ATR) of DRDO, located at Chitradurga, Karnataka. The Chinook helicopter lifted off with the RLV at 06:30 hrs and had a combined mode flight for about 35 minutes to achieve the required pillbox conditions. As intended, when the flying parameters were achieved at about 4.5 km above the mean sea level, the RLV was released from the Chinook helicopter. After separation from the helicopter, RLV had a controlled descent by navigating autonomously to maneuver the vehicle to the runway and landed successfully within 60 seconds. Even though an intentional lateral shift of 100 m was provided before release, RLV landed flawlessly on the runway as predicted, thereby validating the robustness of the onboard autonomous navigation, guidance & control system. Further, the performance of the landing gears and ground systems was satisfactory. Experimental data from this mission will further aid the developments towards the orbital re-entry mission of the winged Reusable Launch Vehicle.
- **Test Vehicle (TV):** A new vehicle was developed as a low-cost test platform to carry out various experimental missions for in-flight functional testing of Crew

Escape System (CES) for Gaganyaan, Vertical Take-off and Vertical Landing (VTVL) technology demonstration, space tourism, etc. The new vehicle called the Test Vehicle, is configured as a single-stage vehicle based on a liquid propulsion system derived from the L40 strap-on stage of GSLV. The first developmental flight of the Test Vehicle (TV-D1) was used for the demonstration of Crew Escape System (CES) performance. TV-D1 took the Crew Module (CM) simulator and CES to an altitude of about 12 km and provided a velocity of nearly 360 m/s (Mach 1.2). At that point, CES initiated mission abort and carried the Crew Module away from the Test Vehicle, which got separated and safely descended into the Bay of Bengal, from where it was recovered with the participation of the Indian Navy.

- TV-D1 mission was successfully accomplished on October 21, 2023, from FLP, SDSC, Sriharikota. With this mission, objectives including a) Flight demonstration and evaluation of vehicle systems b) In-flight performance evaluation of CES and c) Evaluation of CM characteristics, deceleration system performance and CM recovery operations were successfully carried out.
- Realisation of the stage for the second developmental flight of Test Vehicle (TV-D2) for validation of the Gaganyaan Crew Escape System completed and the launch is expected during Q4 2024 from SDSC, Sriharikota.

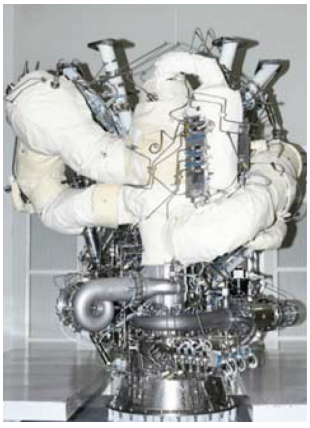
TV-D1 Mission

- **Propulsion systems for Interplanetary missions**
  - **Chandrayaan-3 Propulsion Module:** Chandrayaan-3 used a Propulsion Module to carry the Lander Module from Earth orbit to Lunar orbit. A bi-propellant liquid propulsion system based on MMH and MON3 was used with a 440N main engine and 8 thrusters of 22N thrust. System qualification, flight acceptance testing and flight integration activities were completed.
  - **Chandrayaan-3 Lander Propulsion system:** Vikram Lander used a propulsive landing technique to soft-land on the surface of the Moon. The propulsion system was configured with 4 Nos. of 800N throttleable engines and 8 Nos. of 58N thrusters based on the bi-propellant system using MMH and MON3. System qualification was completed and delivered for integrated Lander Module functional tests including the Integrated Hot test to simulate the closed-loop performance. Flight acceptance testing and flight integration activities were completed as per schedule.

- **Aditya-L1 mission:** Mission studies and simulations for the complex orbital maneuvers including the Earth-bound phase, Trans-L1 cruise phase and L1-centric halo orbit phase had been carried out satisfactorily. The propulsion system is configured for attitude and orbit control during different phases of the mission and orbit-raising operations. A bipropellant system based on MMH and MON3 is used for one 440N engine, eight 22N RCS thrusters and four 10N thrusters.

- **Development efforts towards the human rating of LVM3 for Gaganyaan:**
  - Qualification of all stages of Human-rated LVM3 with respect to propulsion systems has been completed. HS200 static test was completed last year. Vikas engine for the L110 stage and CE20 engine for the C32 stage have undergone qualification testing during this year.
  - Qualification tests of the Vikas engine for the human-rated L110 stage, including 8 tests with a cumulative duration of 890 seconds were completed in 2022 and the final long-duration hot test for a duration of 240 s was successfully accomplished in April 2023. As part of the structural qualification test, the N_2O_4 & UH25 propellant tank was realized, and the qualification test was successfully completed.
  - Towards qualification of the CE20 engine required for the cryogenic upper stage, all the tests have been completed successfully (cumulative duration of 4935 seconds on two engines i.e. E9 & E13) and the engine has been qualified for induction in the Human-rated C32 stage.
  - Casting of solid motor segments for the first unmanned mission (Gaganyaan-G1 mission) has been completed and motor (HS200) preparation activities are in progress. Flight Acceptance Test of CE20 engine (E12) for G1 mission was completed at IPRC. The propellant tank & structures required for the human-rated L110 stage & C32 stage have been realized and the stage preparations are in progress.

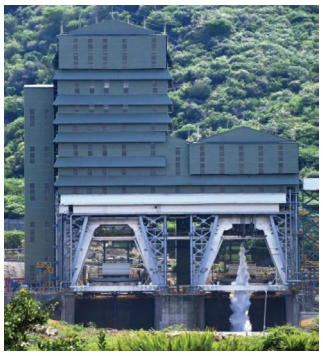
- **Semi-Cryogenic Propulsion System:** The semi-cryogenic system project envisages the design and development of a 2000 kN semi-cryogenic engine and SC120 stage that will provide heavy-lift capability for future Indian Space Transportation Systems.
  - The first integrated test on an intermediate configuration of the engine was successfully carried out on May 10, 2023. The intermediate configuration, designated as the Power Head Test Article (PHTA), comprises of all the engine systems except the thrust chamber. The test is



Power Head Test Article

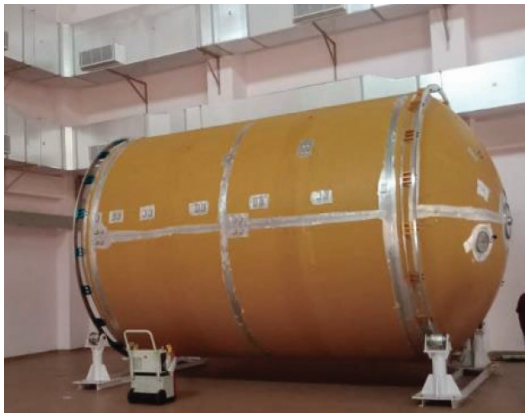
the first of a series of tests planned to validate the design. This test successfully demonstrated the complex chill-down operations spanning about 15 Hrs. duration, meeting all the required conditions for engine start. Successful performance of the test article helps in deriving the sequence of operations for further tests. This test demonstrated the performance of the test facility and power head test article in the first attempt itself.

- The first short-duration ignition demonstration test on Power Head Test Article (PHTA) for a duration of 4.5 s was conducted on July 01, 2023. The test proceeded as predicted till 1.9 s validating the ignition and subsequent performance of PHTA. However, at 2 s, a spike in turbine pressure & subsequent loss of turbine speed was observed and the test was aborted. Detailed failure analysis is being carried out and various simulation tests are being done to characterize the transient behavior.



Power Head Test Article test at Semicryo Integrated Engine Test Facility

- The sub-systems required for the first integrated engine test are in different stages of realisation. Three Isrosene and three LOX propellant tanks for the semi-cryogenic SC120 stage have been realized through industry and the activities towards structural qualification test are being carried out. Three SITS (Semi-cryogenic Integrated Tank Structure), two SPBS (Semi-cryogenic Propulsion Bay structure), and two SCTS (Semi-cryogenic Core Thermal Shroud) structures have been realized through industry and the acoustic test on the Semi-cryogenic Integrated Tank Structure (SITS) has been completed. The realisation of remaining structures & control components for the Semi-cryogenic stage is in different stages of realisation.



LOX Tank

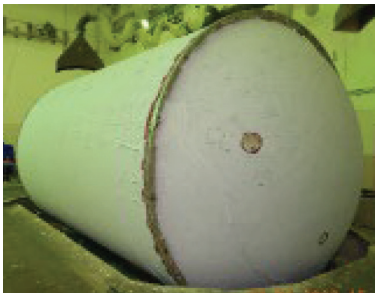
Isrosene Tank

2.5 Space Transportation Systems

SITS Structure

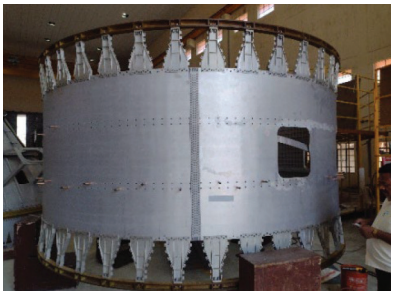
Acoustic Test on the SITS Structure

- **Uprated Cryogenic Stage (C32):** The C32 stage project envisages the design, development and realisation of a cryogenic stage with an uprated engine thrust and higher propellant loading, which will enhance the payload capability of LVM3.
  - Three LH2 tanks, two LOX tanks and three sets of closed Inter Tank Structure (ITSc) have been realized. The structural qualification test for the LOX tank & ITSc at LN2 temperature and acoustic tests on the closed ITSc structure has been completed. Activities towards the structural qualification test for the LH2 tank & ITSc at LN2 temperature are expected to be completed soon.
  - Towards the qualification of the CE-22 engine at 22-ton thrust operation, 2 upratement tests on the E9 engine (cumulative duration of 720 seconds) and 4 upratement tests on the E13 engine (cumulative duration of 935 seconds) have been completed successfully. With this, the engine has been qualified for 22-ton operation in flight.
  - Vacuum ignition test of CE20 E13 cryogenic engine without nozzle closure has been successfully demonstrated for a duration of 2.5 seconds in High altitude test conditions on March 26, 2024. This is the first of a series to validate the capability of restarting the cryogenic engine in space.
  - Integration activities on the propellant tanks and the inter-tank structure are being carried out towards the realisation of the stage for the first unmanned Gaganyaan mission. The acceptance test on the engine identified for the first un-crewed mission has been completed and the engine is being made ready for flight.



LH2 Tank

LOX Tank



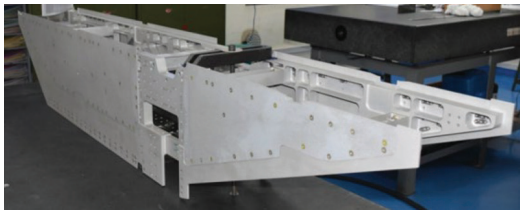
ITSc Structure

CE22 Engine Hot test

- **Development of Critical Technologies for Hypersonic Air-breathing Vehicle with Airframe integrated system (HAVA):** Air-breathing propulsion technology would enable improvement in payload mass fraction of space transportation systems. HAVA flight envisages to demonstrate the accelerated flight of the vehicle under hypersonic conditions using Scramjet. Towards this, several critical technologies were identified for development.
  - The aerodynamic characterisation of HAVA vehicle has been completed. Development of fluid storage & feed system, air intake cowl opening mechanism and GH2-GO2-based ignition system have been completed. Material development and coupon-level testing of TPS materials for air intake ramps and scramjet combustors have been completed.
  - Connected pipe mode scramjet combustor testing demonstrated the air heater and igniter performances for supersonic combustion of Isrosene. The combustor has been refurbished for the next hot test planned at NAL. Towards this, the strut module and SiC-coated carbon-carbon leading edge for the air intake ramp are realized.

2.5 Space Transportation Systems

- A Dual Fuel Scramjet (DFS) flight is scheduled for Q3 2024 using RH560 to demonstrate supersonic combustion with Isrosene as fuel and GH2-GO2 based ignition system. Full engine flow-duct assembly, engine frame assembly, Isrosene tank, GH2 bottle, Fuel Feed System and Fuel injection struts have been realized for the DFS flight.



Engine Frame Assembly

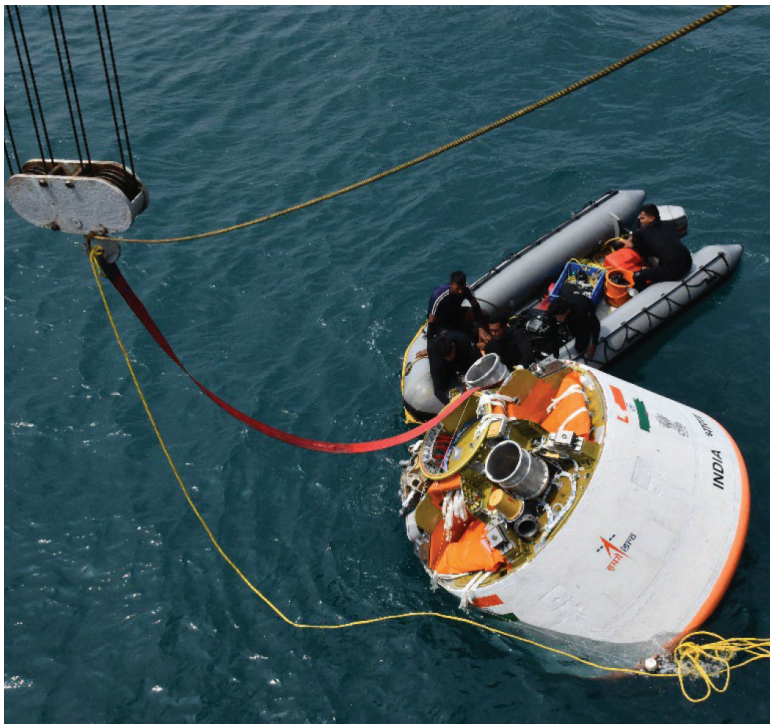
- **Sounding Rockets:** Advanced Technology Vehicle Project conducts sounding rocket launches for the scientific exploration of the middle & upper atmosphere. It also provides a cost-effective platform for testing new technologies before introducing them into launch vehicles.
  - A total of 16 RH-200 rockets were successfully launched during the financial year from TERLS, SHAR, and Kulasekharapattinam. So far till May 2024, 223 successive successful launches of RH200 rockets have been conducted.
  - RH-560 vehicle systems for the flight demonstration of the dual-fuel Scramjet engine have been made ready.

2.6 Gaganyaan

I. Major mission milestone

- Test Vehicle Abort mission - 01 (TV - D1) test flight accomplished on October 21, 2023. Crew Module sub-systems and Crew Escape System performed as intended.
- TV-D1 Crew Module safely recovered from the Bay of Bengal with the help of the Indian Navy on October 21, 2023.

TV-D1 Flight



TV-D1 Crew module recovery

II. TV-D1 Mission

Crew Module [CM]

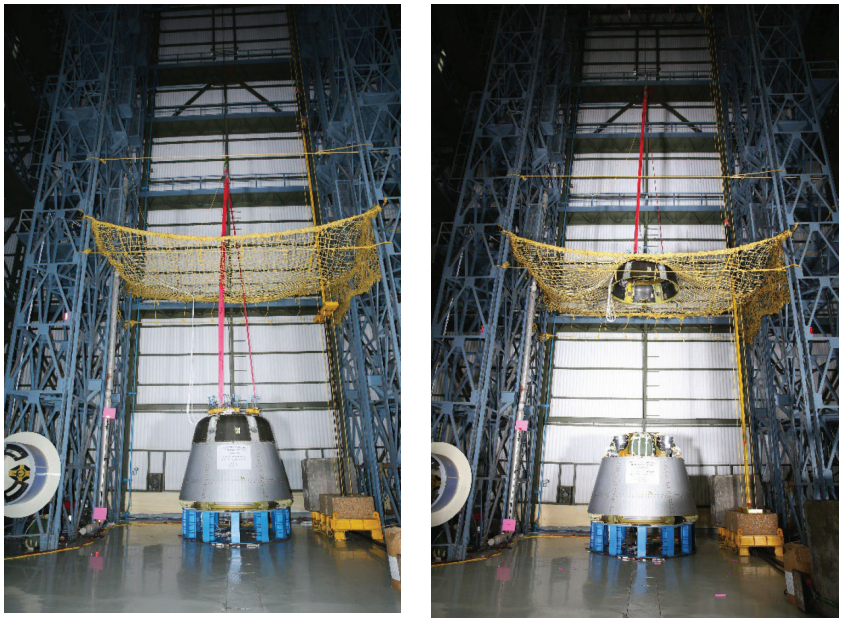
Structure: Structural testing of Crew Module (total 11 nos. of load cases) completed at INSTEF/VSSC. Crew Module and apex cover hardware realized. Interface generation, assembly and integration activities are completed on the hardware subsequently at ISITE, Bengaluru and SDSC. The Crew module underwent an acoustic test at ISITE, Bengaluru followed by a vibration test at SDSC-SHAR.

TV-D1 Crew module after integration

Deceleration systems: Drogue mortar & pilot mortar firing tests on crew module structure completed at VSSC.

Simulated Structures: Realization of all simulated structures required for TV-D1 flight completed. Integrated structural qualification testing of simulated SM Structure & simulated SM FE Ring with CM-SM Separation Joint completed satisfactorily on May 04, 2023, at FAST/ VSSC.

Separation systems: Realization of CM-CES, CM-SM and Apex Cover separation system completed.



Apex cover separation Test

Avionics: TV-D1 Crew module various simulation tests completed. Testing of the Location transmitter package (physically located at SAC, Ahmedabad) with the COSPAS-SARSAT (GEO-SAR) system is conducted at ISTRAC, Bengaluru. End-to-end testing of UHF beacon completed.

Crew Escape System [CES]

Thermal Protection System (TPS) layer application on CES Conical Shroud (CECS) and CES Ogive Shroud (CEOS) hardware completed. All Crew Escape System [CES] structures, motors and avionics components were realized for the mission. LEM Adaptor (LEA) vibration test (random & sine) completed for all three axes at ISDTF, VSSC.

III. IADT-01:

IADT Crew Module 1st Structure realised at industry and handed over to HSFC on March 24, 2023. The same hardware was utilized to carry-out the Ground resonance test (GRT) at SDSC.

2nd Crew Module structure realized for Integrated AirDrop Test and delivered to VSSC for final integration activities. Integration activities commenced on the structure.

Avionics packages are realized for IADT-01 and are available.

IV. G1 till H1:

Crew Module [CM]

Realization of Crew Module flight hardware is nearing completion. Crew Module 2nd un-pressurized structure realized and utilized to carry out shock survivability tests at VSSC. G1 ECLSS – Cold plate configuration with bracket mounting and dummy package mounting completed. Deck Plate optimization rework completed and ready for integration. Re-vibration of Check valves, Filter Venturi and Fill and Drain Valve completed as per TVD levels. FAT completed for 8 nos. of 100N injector.

Service Module [SM]

Service Module 1st hardware identified for G1 is near completion. Dry assembly of the outer structure completed. Bonding of longerons with three runs completed. Shim requirement for Deck assembly completed. Primary bonding of vertical deck completed. And post bonding drawing of the vertical deck was also completed. Structural analysis for the defined load cases for static test configuration completed. Qualification of temperature sensor on Inconel gas tank initiated. Fabrication of diffuser plate for VD02 panel initiated.

V. Qualification/ Acceptance Test Programme:

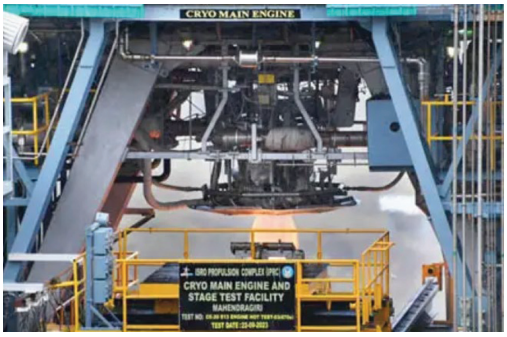
a. HLVM3 - L110 - VIKAS Engine Qualification

- Final long-duration hot test

L110 Vikas engine hot test

(HS-03) of human-rated - L110 Vikas engine successfully completed on April 06, 2023 at IPRC.

b. HLVM3 - Cryogenic CE20 - E13 Engine Qualification



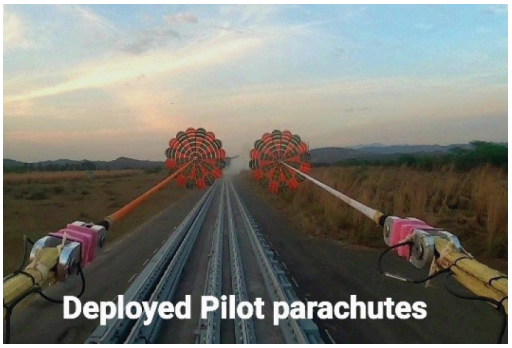
E13 Engine HT-03

- Long duration test (HT-02) successfully carried out (for 720 seconds) at IPRC, Mahendragiri on August 30, 2023.
- Cryogenic engine hot test (E13 Engine HT-03): Long duration test successfully carried out (for 630 seconds) at IPRC, Mahendragiri on September 22, 2023. All tests with respect to human rating of the stage completed.
- Flight acceptance hot test of CE-20 E12 Cryogenic engine successfully conducted for 25 seconds in High Altitude condition at IPRC on October 19, 2023.

Flight Acceptance test of E12 Engine for G1 mission in High Altitude test facility

c. Deceleration systems

Phase- I Rail Track Rocket Sled (RTRS) test of drogue parachutes completed at TBRL, Chandigarh on May 19, 2023. Grid Fin functional deployment test with aero-assisted load using the hydraulic system successfully completed on July 31, 2023, at ASMG, VSSC. Series of Drogue Parachute deployment tests successfully completed at Rail Track Rocket

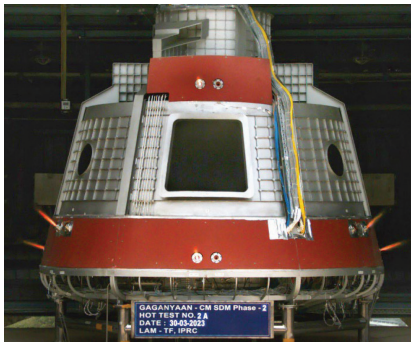


Sled (RTRS) facility of TBRL, Chandigarh from August 08-10, 2023. Drogue Mortar & Pilot Mortar Firing Tests on Crew Module Structure completed. The batch Test of Drogue Mortar was Carried out successfully.

d. Separation systems

System Level Functional test of CM-SM Separation system completed on June 16, 2023 at VSSC. Apex Cover separation test completed at Zero-g VSSC on August 21, 2023. CM-CES Separation System: System level functional test completed as part of CM shock survivability test, at ASMG/ VSSC. Functional qualification test of CMF-SMF separation system carried out at ASMG/VSSC.

e. Crew Module System Demonstration Tests (CM-SDM) Phase-II for CM propulsion

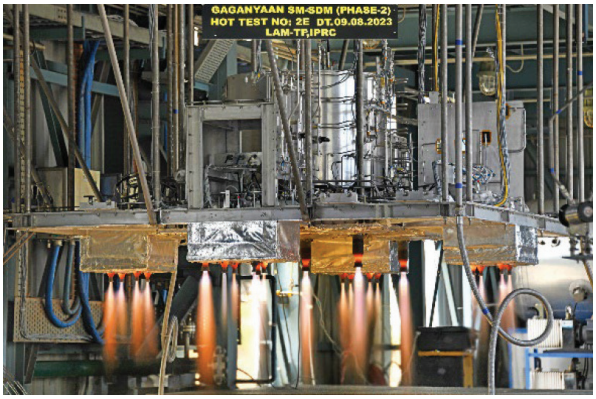


- **1st hot test [Test-2A]** of Crew Module- The 1st test [2A] for CMPS characterisation [5 sec ON (Primary thrusters), 5 sec OFF and 5 sec ON (redundant thrusters)] is completed on March 30, 2023.
- CM-SDM Phase-II tests: The **2nd test [2B]** for 650 sec. successfully completed on April 05, 2023.
- Crew Module Propulsion System-CM-SDM Phase-II tests: The **3rd test [2C]** for 50 sec. (pulse mode) successfully completed on April 13, 2023.
- Crew Module Propulsion System- CM-SDM Phase-II tests: The **4th test [2D]** for 81.52 sec. (pulse mode) successfully completed on April 19, 2023.
- Crew Module Propulsion System- CM-SDM Phase-II tests: **5th test [2E]** to **7th test [2G]** completed on April 27, 2023.

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

2.6 Gaganyaan

f. Service Module System Demonstration Tests (SM-SDM) Phase-II for SM propulsion



- **Test-2A** (Reference test) for 250 seconds on July 19, 2023.
- **Test-2B** (RCS thrusters & LAM engine calibration) for 723.6 seconds on July 26, 2023.
- **Test-2C** (Orbit circularization) for 350 seconds on July 26, 2023.
- **Test-2D** (De-boost) for 700 seconds on July 27, 2023.
- SM propulsion- System Demonstration Model (SDM) **Test-2E** was carried out for 670 seconds on August 09, 2023 simulating the SM-based abort condition.

g. 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). All motor structure & nozzle realization and casting activities were completed before the respective static test.

HPM & LPM Static Test: High altitude Pitch Motor (HPM) Static Test (ST-03) successfully carried out at VSSC on March 15, 2023.

HEM Static Test: The high altitude Escape Motor (HEM) batch static test (ST-04) was completed at SDSC, SHAR on March 20, 2023. HEM batch static test (ST-05) completed at SDSC, SHAR on April 28, 2023. HEM ST-06 completed at SDSC, SHAR on May 19, 2023. HEM ST-07 was completed at SDSC, SHAR on May 12, 2023.


HEM Static Test


CJM Static Test

CJM Static Test: 2nd Static test of CJM was completed at SDSC, SHAR on February 13, 2023.

h. Acoustic test

Phase 1 acoustic test completed successfully on April 19, 2023, at NAL, Bengaluru.

TV-D1 Ph-I Acoustic test

TV-D1 Ph-II Acoustic test

GRT Setup

Crew Module Acoustic test (Phase-II) completed on TV-D1 Crew Module at ISITE on August 10, 2023.

i. Ground Resonance Test GRT

Base fixed boundary condition GRT completed on July 21, 2023, at SDSC, SHAR.

j. Crew Module Vibration Test

TV-D1 Crew Module Vibration test completed (all three Axis) at SMP-ETF, SDSC on August 25, 2023.

VI. Readiness of Launch Complex Systems

a. Second Launch Pad

Structural modification works - Fabrication of machining components for autolocking system completed. Shaft spline cutting and inspection completed. White room – White room panel testing completed. Bubble lift-all works completed and lift commissioned. Zipline system & Landing tower with CESB – Detailed design of Zipline system completed. CESB building construction completed up to 10.5 m FFL level.

b. Orbital Module Preparation Facility (OMPF)

Modular wall, Aft-end and fore-end access tower, EOT crane erection work, AC installation and other civil work inside the OMPF CM, SM and MAL bay completed. TV-D1 integration of CES Aft-end stack and Fore-end stack successfully carried out in OMPF building.

Orbital Module Preparation Facility [OMPF]

c. Gaganyaan Control Facility (GCF)

Cable race way works & FDA systems wiring completed. Wall panelling completed. False flooring and false ceiling were completed in all areas. Data cable laying in Orbital Module Control Centre (OMCC) completed.

Gaganyaan Control Facility [GCF]

VII. Recovery

Initial recovery trials of the Crew Module commenced on February 7, 2023 at the Water Survival Test Facility (WSTF) of the Indian Navy, at Kochi. Realization of 2 nos. of Crew Module Recovery Model (CMRM) completed. Harbour trials for the Gaganyaan Recovery operations were completed at the Naval Dockyard, Visakhapatnam.

VIII. Crew Training

Conduct of training and lectures for HLVM3, Aerothermodynamics and IISc courses for 2nd semester commenced. Cabin and communication systems for Gaganyaan Static Mock-up Simulator (SMS) realized and flagged off from SAC.

Cabin and communication systems Flag-off

IX. Programme management

The Gaganyaan project campaign office is set-up and operational at LVPO, zero-point, SDSC.

X. Procurement & Budget

The procurement actions are being carried out in-line with the programmatic progress and with respect to the overall project timeline. Based on the programmatic requirements, the BE allocation for FY 2023-'24 was ₹1200.0 Cr. However, after a detailed review mid-year, the RE allocation of ₹1090.0 Cr. was finalized for the FY 2023-'24. Expenditure as of November 14, 2023 is ₹622.67 Cr. which is 57.13 % of the RE 2023-'24. Plans are in place for achieving the expenditure targets. Realization of critical hardware at industries being fast-tracked. Vendors meet being organized periodically towards sensitizing the criticality of accomplishing the Gaganyaan Mission in a time-bound manner. Being a flagship programme of Govt. of India, top priority demanded at work centres, industries and all in-house facilities. Parallel realization is envisaged at various work centres. Availability of FIM being addressed.

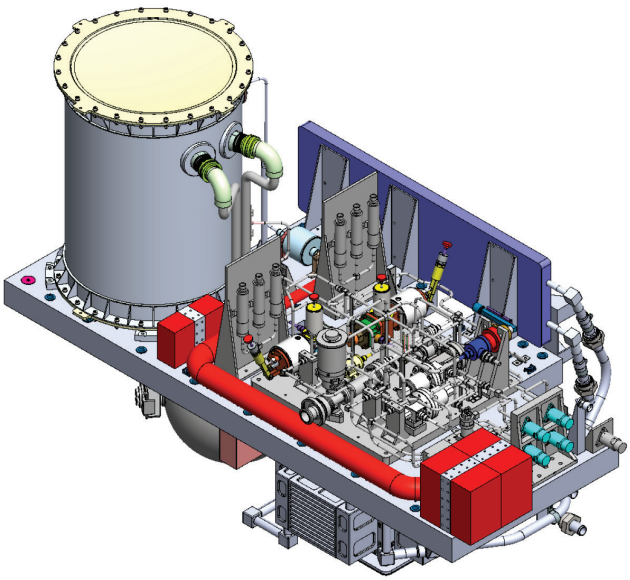
1. Environment Control and Life Support System

ECLSS provides a suitable human habitable earth-like environment in the Crew Module, during all the phases of the mission. ECLSS provides the crew with breathable air, a habitable environment, food and water to support crew for the entire mission duration.

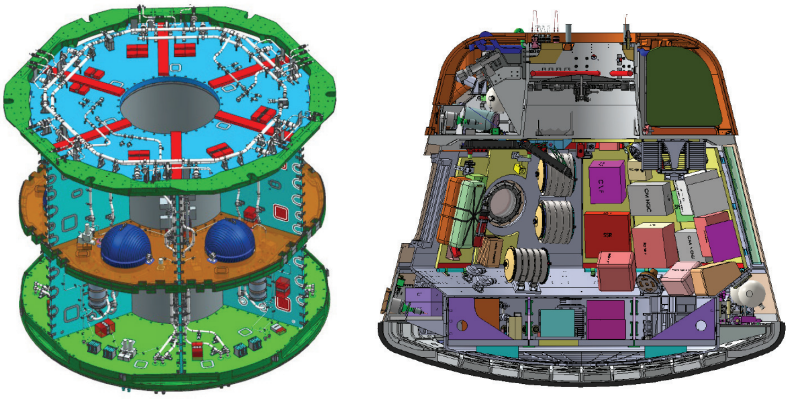
- Detailed planning of ECLSS facility completed, obtained necessary clearances and approvals. The foundation stone for ECLSS Integration and Test facility laid by Chairman ISRO on January 18, 2023.


Foundation laying ceremony

- Received Flight suit and crew seat items (as per contract no HSMN-2019 000 705 01 01, Batch 5 and 6) from GK, Russia.
- For the G1 mission, a demonstration of ECLSS in reduced configuration (Thermal control system and Cabin pressure control system) is planned. Configuration, design and accommodation are completed and clearance for the same is obtained from the respective DRT committee. Hardware realized and testing is under progress.
- Systems engineering of ECLSS in the crew module and service module is completed. Layout drawings were released for hardware realization.



ECLSS configuration for G1 mission



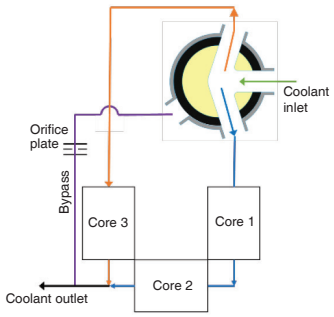
Layout and accommodation in SM and CM

- A Condensate Collection Tank for storing condensate water in the crew module is designed. Realization is under progress in industry.

Condensate collection tank

- The diverter valve of THCS for cabin temperature control is designed and realized. It is required to divert the coolant flow through different cores of the heat exchanger for temperature and humidity control.

Diverter valve



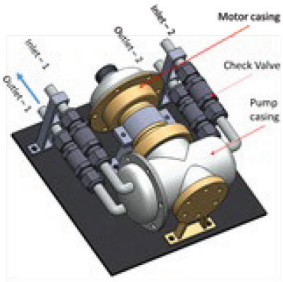
- Manual Condensate Pump is designed and is under realization. It is required to pump out water from the hygroscopic foam inside the condensing heat exchanger to the condensate tank for storage.

Manual Condensate Pump

2.6 Gaganyaan

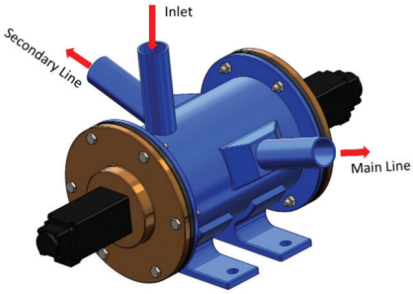
- Multi-Purpose Valve (MPV) is designed and realisation is in progress. It Allows air pumped into the condensate tank to return to the cabin.
- The Seawater Pump design is completed and fabrication drawings are generated. It is required for the thermal management of cabin post-landing.

Multi-Purpose Valve

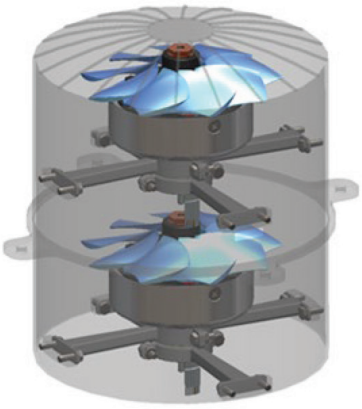


Seawater Pump

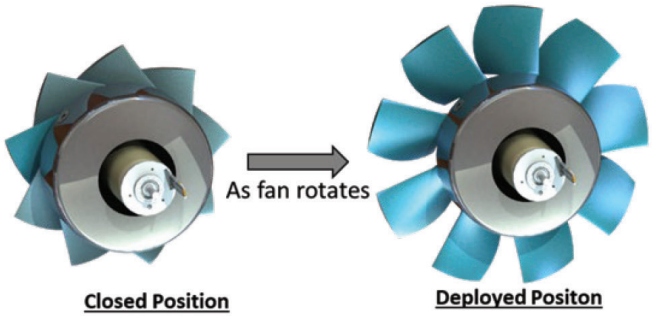
- Flow Switching Unit design is completed and fabrication drawings are generated.
- Deployable Fan design is completed. Fabrication is in progress in the industry.



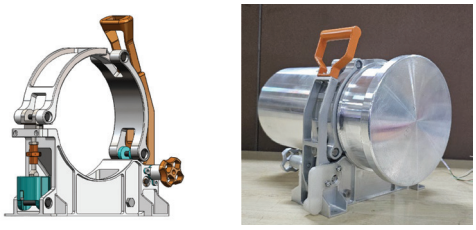
Flow Switching Unit



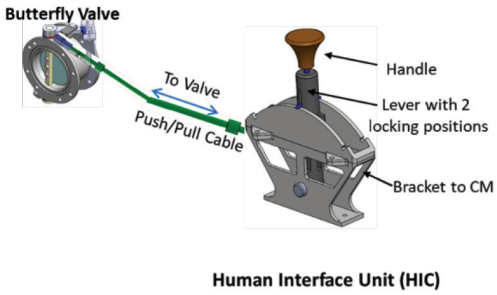
Deployable Fan



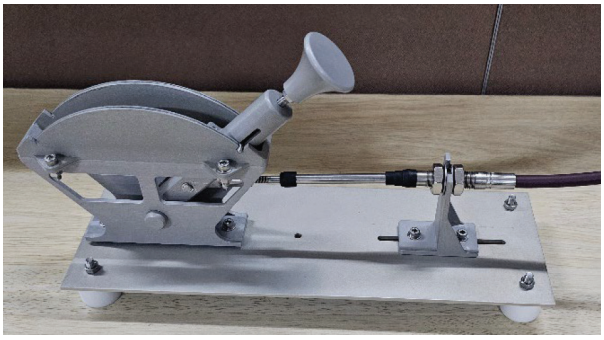
- Quick Action under-centre Mechanism (QAM) design for mounting fire suppression system completed and hardware realized. It provides quick response for fire suppression by crew.
- Post Landing Ventilation System design for cabin ventilation post touch down is completed and the engineering model realised.



Quick Action under-center Mechanism



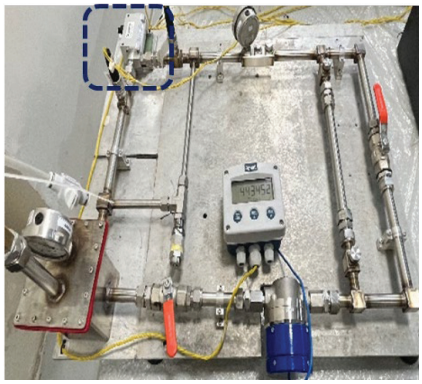
Human Interface Unit (HIC)



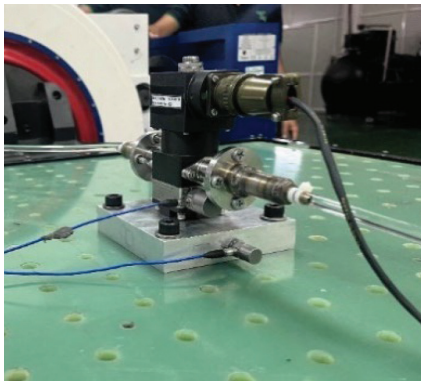
Post Landing Ventilation System

- Qualification test plans of THCS components have been presented and cleared by the Test Review Board. Functional and environmental tests for components e.g. pumps, SV, PRV, CV, Filter etc. are completed in the industry.
- Initial Standard Room Condition (ISRC) tests have been completed for the following components as part of Qualification: 1) Inner Loop Pump, 2) Outer Loop Pump, 3) Solenoid Valve, 4) Check Valve, 5) Filter, 6) Pressure Relief Valve, 7) Axial fan for Non-condensing HEX, 8) Axial fan for Condensing HEX, 9) Cabin fan and 10) EMC pump.
- Environmental Tests (Sine Vibration, Random Vibration and Shock) have been completed for the following components as part of qualification: 1) Inner Loop Pump, 2) Outer Loop Pump, 3) Solenoid Valve, 4) Check Valve, 5) Filter, 6) Pressure Relief Valve, 7) Axial fan for Non-condensing HEX, 8) Cabin fan and 9) EMC pump.
- Thermo-vacuum test has been completed for the following components as part of qualification: 1) Outer Loop Pump, 2) Solenoid Valve, 3) Check Valve, 4) Filter, and 5) Pressure Relief Valve.
- EMI/EMC test has been completed for the following components as part of qualification: 1) Outer Loop Pump and 2) Solenoid Valve.
- Final Standard Room Condition (FSRC) tests have been completed for the following components as part of qualification: 1) Check Valve, 2) Filter, and 2) Pressure Relief Valve.

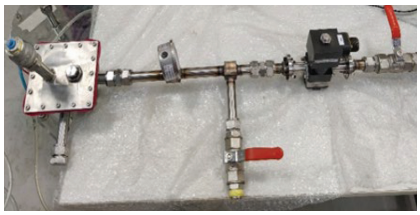
2.6 Gaganyaan



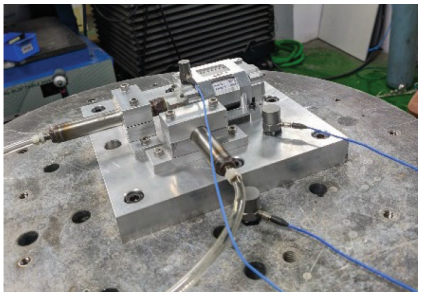
Pump performance tests



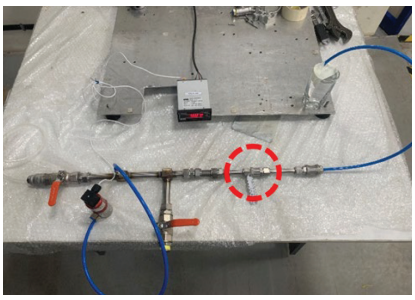
Pump Vibration/Shock test



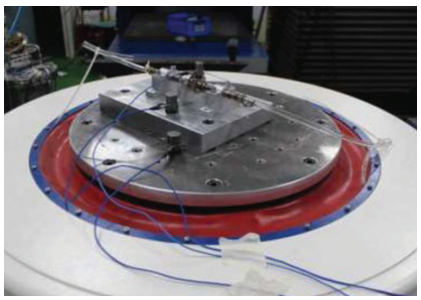
Solenoid Valve performance tests



Solenoid Valve Vibration/ Shock test

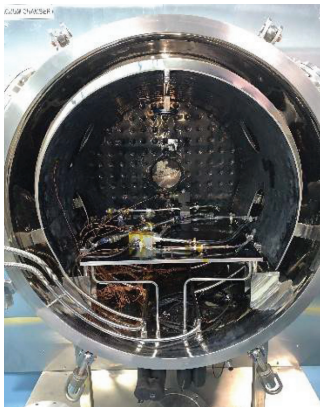


Check Valve performance test



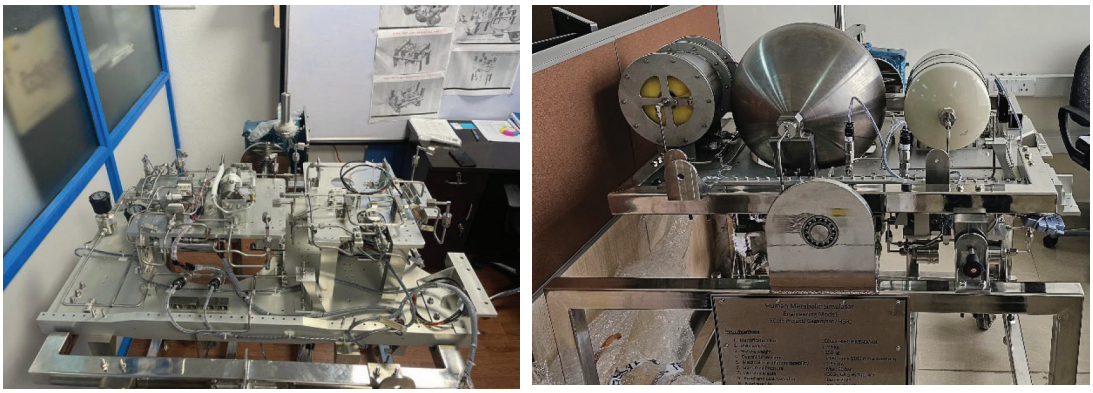
Check Valve Vibration/ Shock test

FEMC pump performance test



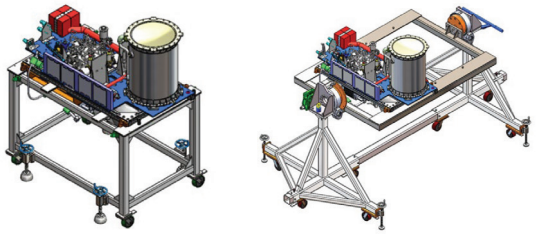
Thermo-vacuum test

- Completed raw material procurement, testing and clearance for the G1 mission.
- Welding procedure specification finalized for welding of plumb line.
- ECLSS integration and test facility layout and equipment specification finalized. Procurement is in progress.
- For testing the ECLSS on the ground and in an uncrewed mission, A Human metallic simulator is configured, and designed and an engineering model is realized.

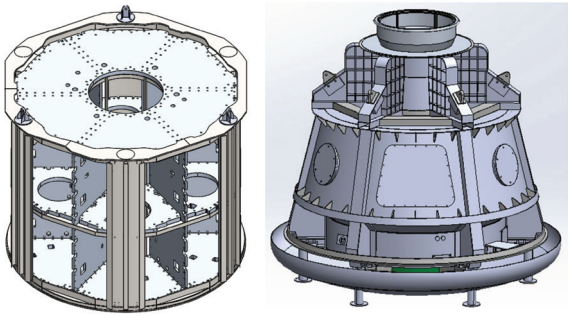


Human metabolic system-development model

- For integration of the ECLSS system in the crew module, various MGSE fixtures are under realization.
- Functional simulator and integration mock-up structure for service module and crew module is configured and designed for integrated ECLSS testing and integration activities.
- Human-centric product design is completed. Prototypes are realized. Qualification testing is in progress at various DRDO labs.



Static fixture and Tilting fixture



SM and CM Functional simulator and integration mock up Modal

2. Crew Training Simulators

Astronaut training needs to be carried out to prepare the Gaganyaan Crew for all the conceivable situations including contingencies and equip them to manage all the mission situations. Crew Training Simulators identified for Gaganyaan mission are Independent Training Simulator (ITS), Virtual Reality Training Simulator (VRTS), Dynamic Training Simulator (DTS) and Static Mock-up Simulator (SMS).

Independent Training Simulator (ITS)

ITS is a table top simulator primarily aimed at familiarization of the Crew with 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 the procedural training for various crew activities including Crew response training during off-nominal scenarios.

ITS Set-up

ITS has four main components:

1. Simulation environment and hardware interface system.
2. Simulation system.
3. Mission team console.
4. Trainer console.

Current Activities:

- The initial version of the Simulator was developed and used for the collection of feedback from the Astronaut designers. Based on the feedback from them, the updates required in the Console and display pages were identified. This will be realized as a Version 2 simulator. Necessary updates in hardware and software were identified and implemented.
- The console with the updated hardware and software is realized and ready for integration. The simulation software is also ready for integration. The console in the format of emulation software is also designed and ready for experience.

Virtual Reality Training Simulator (VRTS)

VR simulator uses technology that enables users to interact with a computer-generated

environment that simulates physical presence and interaction by artificially creating sensory experiences using a special human-computer interface equipment. Usually, head-mounted displays and hand-tracking systems are employed to enable the user to observe, move around and manipulate the virtual environment.

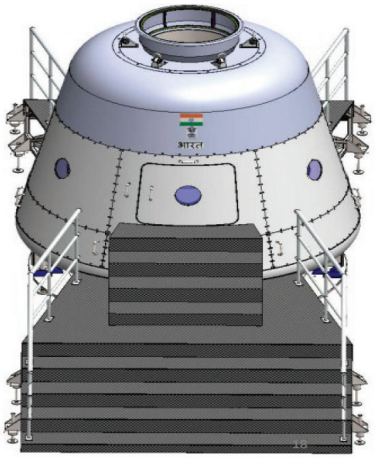
A typical Virtual Environment

Current Activities:

- Phase 1 simulator was realized and available for experience. Based on the experience of version 1, updated design requirements were worked out for the phase 2 simulator and an order was placed with the vendor for end-to-end realization.
- Initial inputs have been shared with the vendor to initiate the design including story board, CAD model of the Crew Module, and operations in the module as well as system-level descriptions.

Static Mock-up Simulator (SMS)

Static Mockup Simulator provides a close to realistic ambience and acquaintance with the Gaganyaan-CM including the distance and approach estimation of the crew control buttons and display 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 a near-real experience of the crew.



SMS Structure

Current Activities:

- The simulator configuration was defined and requirements were given to various design agencies for subsystem realization including Crew Module, ECLSS, Crew seat, cabin subsystems etc.
- For the Crew Module, the design of the structure was completed including reviews and an order was placed with the vendor for the realization of the CM structure, Dummy packages, Crew seat, Cabin System, etc.

- Various ECLSS subsystems were received for integration. Console and various cabin subsystems were also received for integration. The assembly sequence is prepared for mounting packages and decks inside the structure. Plan of electrical harnessing was discussed with the integration team. Electrical interface details were prepared for all the power supplies and packages and shared with the integration team.

- The Crew Module structure is expected in November first week and on receipt, the integration of various subsystems in the module is planned and deployed for training.

Dynamic Training Simulator (DTS)

DTS provides a 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.

Dynamic Motion Platform

Current Activities:

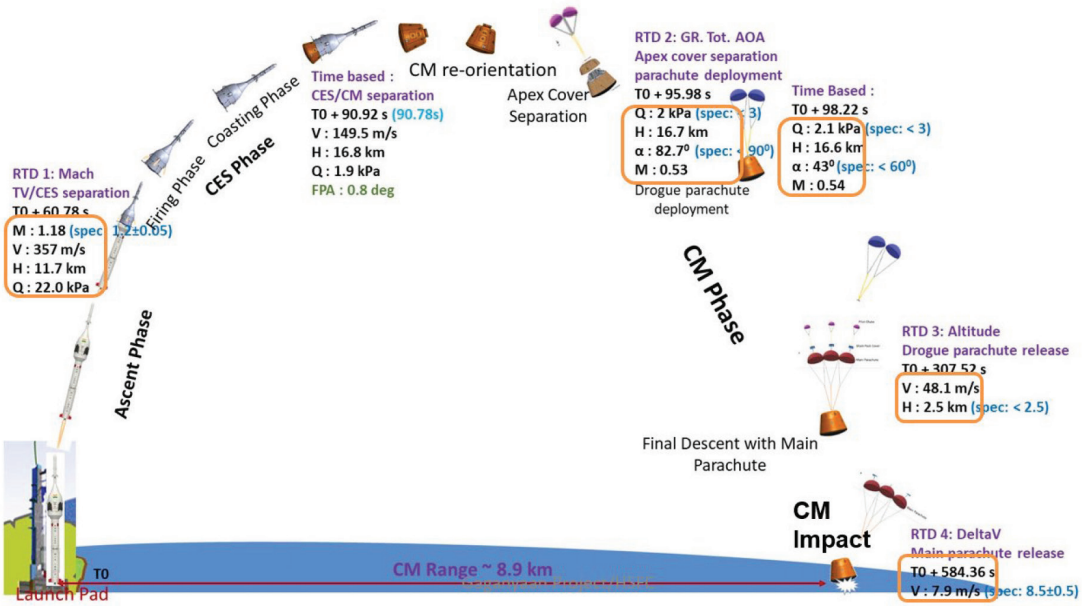
- An overall configuration of the dynamic simulator was designed including various subsystems, interfaces, specifications etc. A detailed RFP document for end-to-end realization of the simulator by a qualified vendor was prepared.

- The discussion was conducted with various vendors, domestic and international and after a lot of clarifications regarding the experience of the vendors in the realization of the simulator, suitable vendors were identified for the simulator realization.

3. Mission

TV-D1 Mission

An integrated mission plan for demonstrating the safe escape of the Crew from a simulated mission abort situation in a TV-D1 flight was generated. Mission definition, requirements, objectives, sign convention documents, Crew Module (CM) vehicle data document and event sequence documents for mission design were prepared. The documents enabled the implementation of event sequence and performed detailed mission simulations to identify trajectory parameters as well as appropriate window timings to make on-board Real-Time Decisions for the safe descent of the Crew Module under parachutes. The planned mission scheme worked flawlessly in the TV-D1 mission and preliminary post-flight analysis of flight data indicates that all major on-board event decisions occurred within specified timings.



Mission Performance in TV D1 Mission

G1 Mission

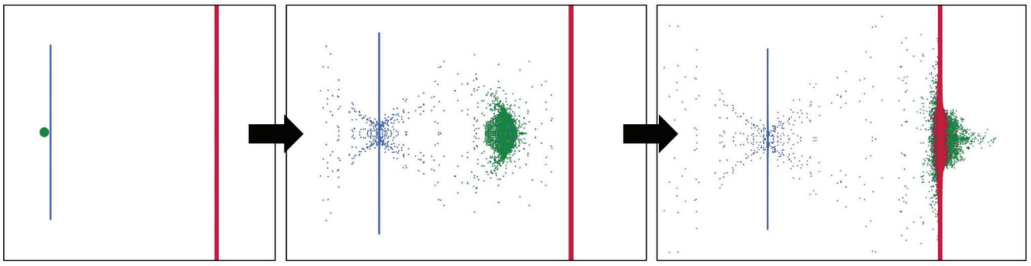
For the major ground qualification test of the Orbital Module Propulsion system, various mission profiles that would demand different sequences of operation of main engines and control thrusters in the Orbital module were generated and subjected to successful testing. Similarly, thruster operation profiles of the Crew Module during normal earth return missions and abort earth return mission were generated and subjected successfully to ground static tests. With these tests, the propulsion system in the Crew Module and Service Module are qualified for mission operations for the upcoming unmanned Gaganyaan G1 mission.

H1 and Other Missions

- To maintain human physiological levels within tolerable limits during the space flight, the best position and orientation of the crew have been specified in terms of the acceptable spine angle of crew in the seated conditions. Physiological standards issued by NASA are taken into consideration while arriving at the spine angle. A Coupled Parachute-Payload Dynamics simulator was developed in C++ language to analyse the rotational behaviour of the crew module and crew during the parachute descent phase and check whether the dynamic behaviour is acceptable from a human physiological view point.

Micro-Meteoroid and Orbital Debris (MMOD)

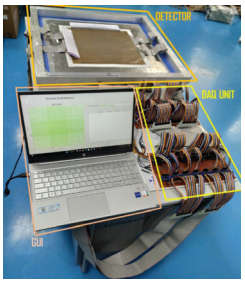
- A realistic assessment of the Orbital Module structure capability to withstand the impact of Orbiting debris (present in the specified 400 km circular orbit) and protect the crew has been completed using the ESA's proprietary software ESABASE. For this assessment, two different world standard space debris flux database catalogues MASTER 8 and ORDEM 3.0 were used to estimate the worst case highest debris flux environment that the Orbital Module can face. This software-based assessment was subjected to validation in hypervelocity impact tests at the Terminal Ballistic Research Laboratory (TBRL), DRDO with an Aluminum projectile of 7 mm impacting at 5 km/s. The performance of the Whipple shield design for protecting the debris impact was as predicted. In addition, Hydrocode simulations were performed to simulate hypervelocity impact with Al2O3 projectiles. Simulation results show a good match with the experimental results obtained from NASA during the Interagency Space Debris Coordination Committee. In continutaion of this activity, S/N (Signal to Noise) ratio and ANOVA (ANalysis Of VAriation) analysis were performed on a set of 16 Hydrocode simulations, to identify the percentage contribution of each parameter and the parameter combinations resulting in extreme results.



Al_2O_3 ball impacting on Whipple shield

- As a technology development Effort to detect the impact of Orbital debris on the orbital module in real time, developed an orbital debris impact detector consisting

of the resistive grid and acoustic sensing. Bench bench-level resistive grid system was demonstrated. Worked out a logic using acoustic sensors for location determination using trilateration of hyperbolas.



Resistive Grid Detector Setup

Human Factors Engineering / समानव कारक अभियांत्रिकी

Human Strength Measurement equipment has been installed and commissioned at HSFC. The equipment can generate the maximum voluntary force that a crew can exert which is important for the design of crew interfaces. Moreover, it can generate inputs for deriving scaling factors for all relevant joints of the musculoskeletal model and establish an Indian population-specific strength database for future space flight missions.

Activities including a comparison of human strength data from NASA HIDH (Human Interface Design Handbook) with the strength values of Indian subjects for shoulder arm in/out action using the Human Strength Measurement equipment have been completed. A simplified musculoskeletal model of humans was also developed, based on the physiological cross-section area for elbow flexors.

Measurements of isokinetic and isometric strength data of humans using the strength measurement equipment have been initiated to modify the default European human muscle models present in the commercially procured musculoskeletal analysis software.

Human Strength Measurement Equipment Installed at HSFC

Human ergonomics analysis has been carried out with a dynamic model of an Arm to optimize the posture of the Arm for maximum comfort within a given bounded volume. The torque data derived from in-house experiments were then used in the Arm model to predict the end effector force at different postures.

A comprehensive assessment of all Gaganyaan mission scenarios was made to identify the demands for manual operation of ECLSS control valves under different flight environmental conditions like low/high gravity, crew unsuited/suited (pressurised and unpressurised) and crew restrained/unrestrained conditions.

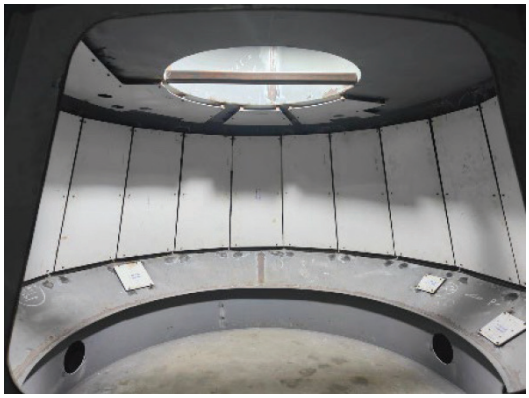
4. Mechanical Systems

Static-Mockup Simulator for Crew Training (SMS-CTS)

- Design of handling ring, hatches, simulated decks, packages, & Crew Seat Assembly through welding route completed.
- SMS-CTS Crew Module Internal layout generated and its assembly sequence finalized.
- Scheme finalized for load testing of SMS-CTS structure.
- Fabrication of the twin walled SMS CTS Structure and assembly of decks with structure completed.

Static Mockup – Crew Training Simulator

CTS CM Structure



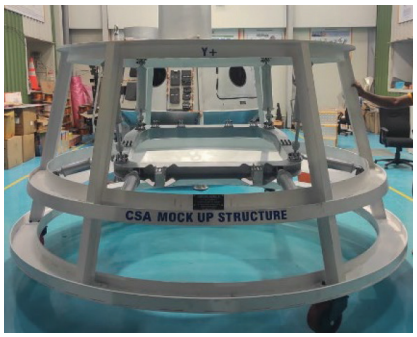
CTS Structure Inner view with Decks assembled

Conical Panels

Apex Cover

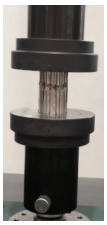
Crew Seat Assembly (CSA)

- Demonstrated the negative **DoF (Degree of Freedom) of CSA** (in locked condition) with realised CSA mockup structure using 100N modal shaker.
- Design and analysis of CSA for the G1 mission carrying Half humanoid and ECLSS deck completed. Detailed CAD model generated for G1 CSA.
- Detailed study carried out for CSA attachment with respect to **number of linkages and its orientation**. Configuration finalized based on overall stiffness and Dynamic response index.
- Seven different configurations of pallet frame were studied. Topology optimization was also carried for the selected configurations.



CSA Mockup structure

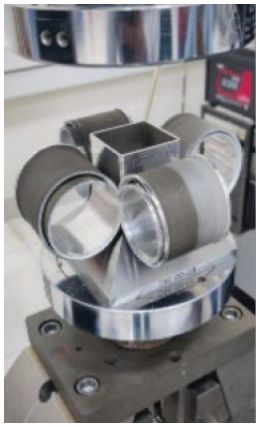
- **Integrated non-linear structural analysis and multibody dynamic studies** were carried out for CSA with seat, pallet and attenuators for the selected configurations of pallet frame.
- **Indigenous seat bucket** analysis completed with welded configuration and model developed for riveted configuration.
- Attenuation System Development
  - For **Honeycomb based attenuation system**, configuration design and Structural analysis (non-linear) was carried out. Honeycomb sandwich stacks were realized and tested using UTM. Mockup model realized with honeycomb based attenuation system.



Honeycomb Stack UTM Test

Mockup model for honeycomb attenuator

  - For **Splitting & Curling based attenuation System**, Finite Element Analysis (FEA) carried out for splitting & curling trials using damage modelling. UTM tests were carried out with different tube and dye configurations based on literature.
  - For **Wire Bender based attenuation system**, FEA carried out for wire bender configuration to achieve the desired force. Test setup configuration for characterize the wire bender attenuation system worked out.



Splitting & Curling UTM Test

- Technical specifications finalized for Anthropomorphic Test Devices.

Indigenous Viewport Development

- Engineering model of viewport realized through 3D printing.
- Viewport **structural and transient thermal analysis** carried out integrated with the crew module's internal and external panels.
- **Axisymmetric thermo-structural analysis** carried out for various thicknesses of thermal seals, based on literature.

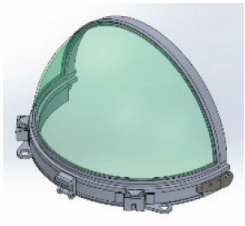
2.6 Gaganyaan


3D printed components for engineering model

Indigenous Viewport engineering model

Helmet Visor Assembly

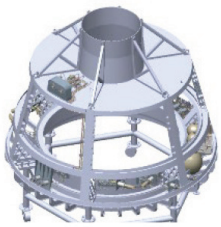
Helmet Visor Assembly configuration design and preliminary structural analysis completed for field training suit.



Helmet Visor Assembly configuration

CM Mockup for Water Calibration

Design and analysis of Crew Module mockup structure (welded route) for water calibration activities completed.



Water Calibration Mockup with Propulsion Systems

Realisation of CM Structure for Integrated Air Drop Test (IADT)

- 15CDV6 Ring, Forgings & Sheets, AA2014 Forgings, 8CD12 Filler Wire were realized for the components & subsystems for the CM Structure.
- Realised the Apex, Dome & Conical Subassemblies and integrated them to complete the CM Structure.
- Fabricated & Supplied 02 Nos. of CM Structures for IADT to validate Gaganyaan Parachute systems.

1st CM Structure realised for IADT

2nd CM Structure realised for IADT

Realisation of Simulated SM Structure & SM FE Ring for TVD1, PAT Missions

- Realised & Delivered 04 Nos. of Simulated SM Structures
- Realised & Delivered 03 Ns. Of SM Simulated FE Rings

SM Simulated Structure & SM FE Ring

Mechanical Ground Support Systems Fabrication Related

- Realised & Delivered the Ground Support Structure for the CM-CES Stack Acoustic Test.
- Realised the CM-CES Link Brackets for the Acoustic test of TV at NAL.
- Realised & Delivered the Orbital Module Handling Ring for Transportation & handling of Orbital Module.

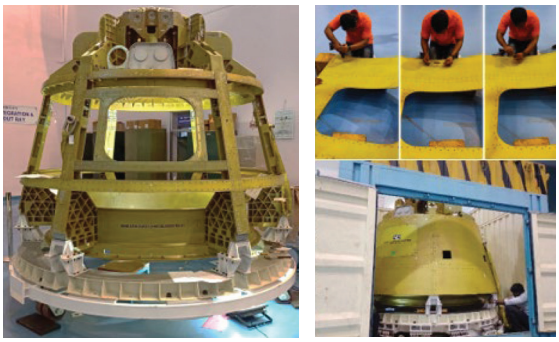
Ground Support Structure

Orbital Module Handling Ring for IADT

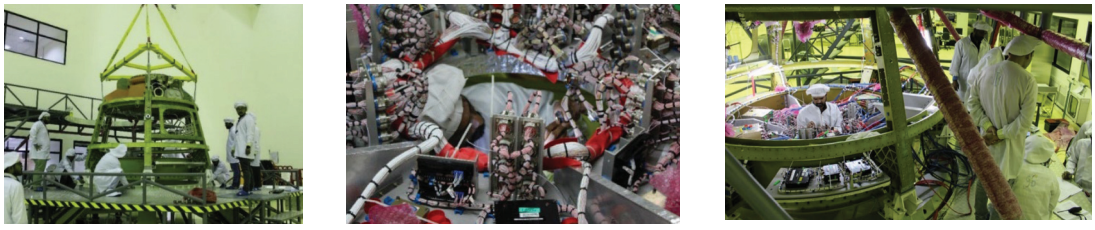
5. Assembly System Testing and Recovery

TV-D1 Activities

- ASTRE commenced activities on the TV-D1 Crew Module (CM) structure at VSSC in March, 2023. The Crew Module was then transported to AITF-2, ISITE for further integration activities.
- TV-D1 Crew Module (CM) integration activities at AITF-2, ISITE began from April, 2023 onwards. Several activities including flight harness testing & transfer, flight deck mounting, etc. were completed towards the commencement of Phase-1 checks.



Commencement of Integration activities on TV-D1 CM Structure at VSSC



TV-D1 Crew Module integration activities at AITF-2, ISITE

- Phase-1 checks for TV-D1 CM were commenced in April 2023. Checks for the Power System, Instrumentation, and NGC were carried out to validate the integrated Crew Module avionics.

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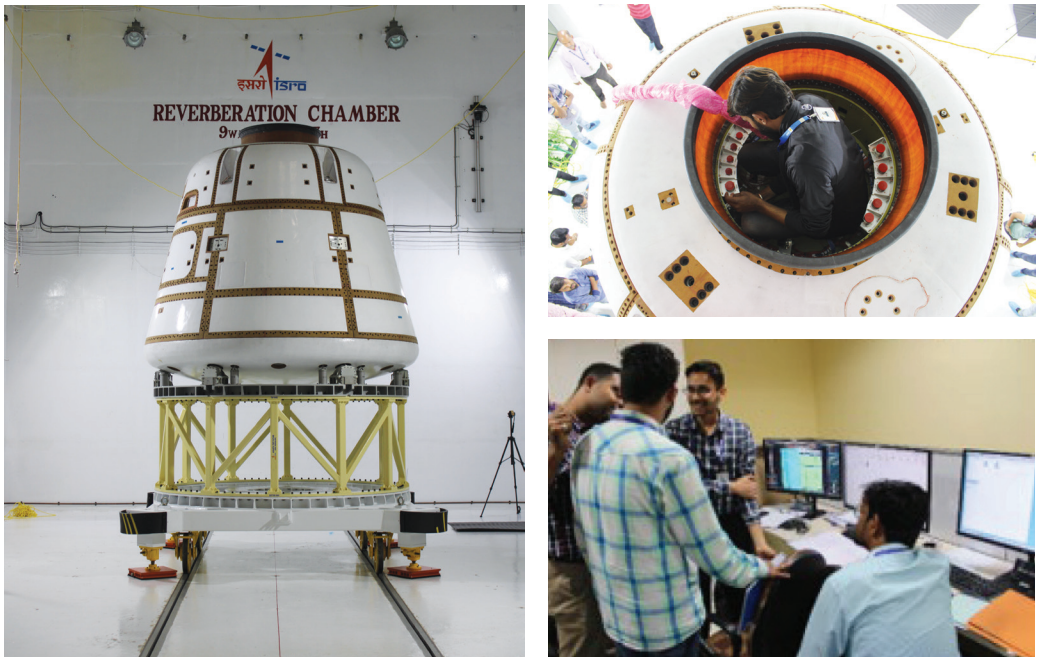
TV-D1 CM Phase-1 checks at AITF-2, ISITE

- Chairman, ISRO visited the premises on July 24, 2023, during TV-D1 CM Phase-1 Checks and integration activities at AITF-2, ISITE.

Visit of Chairman, ISRO for Phase-1 TV-D1 CM Activities at AITF-2, ISITE

- Acoustic Tests for TV-D1 CM were completed on August 10, 2023, at ETF, ISITE. Post-test analysis, the Crew Module was cleared for transport to SDSC-SHAR.



Successful Completion of Acoustic Tests for TV-D1 CM at ETF, ISITE

- TV-D1 CM was flagged off to SDSC, SHAR on August 12, 2023. The Crew Module and the checkout systems were shifted to VTF, SHAR towards preparation for CM Vibration Tests.

Flag-off of TV-D1 CM to SDSC-SHAR

2.6 Gaganyaan

- Vibration Test for TV-D1 CM was completed in August 2023 at VTF, SHAR.
- Phase-2 Checks for TV-D1 CM were completed in October 2023 at OMPF, SHAR. Pyro Wiring of CM, assembly & integration of CMEA, and CMEA electrical checks were completed prior to stacking with Test Vehicle and CES.

Completion of TV-D1 CM Vibration Tests at VTF, SHAR

Completion of Phase-2 checks for TV-D1 CM & stacking operations of CM with CES

- TV-D1 mission was successfully launched on October 21, 2023, at FLP, SHAR. All systems, including the Crew Module, performed nominally. Recovery operations were successful for the TV-D1 CM using INS Shakti, and the recovered CM was brought to SHAR for post-flight analysis.
- Activities post recovery of the TV-D1 Crew Module were completed in October, 2023 at AITF-2, ISITE. Post-flight analysis was conducted for all systems; all onboard avionics were disassembled, and preparations for refurbishment of recovered CM were also completed.

TV-D1 launch at SDSC, SHAR with successful CM recovery operations

Successful Disassembly of recovered TV-D1 Crew Module at ISITE

TV-D2 Activities

- A review of TV-D2 CM avionics layout and mounting configuration from the EMI/EMC point of view was studied by the EMI/EMC committee.
- The following documents are CC released
  - Avionics Package list
  - Umbilical Scheme
  - Electrical Architecture
  - Powering scheme
  - Pyro scheme
  - Grounding scheme
- Matched EID for HILs setup is prepared and shared with the URSC team.

TV Checkout – Overall

- Delivery and inspection of items including Power rack, spare racks, PCI cards, LAN & RF cables, completed at vendor site etc.
- 12 Types of Gerber files designed, verified by QC team and PCBs under fabrication at the vendor site.

- HCPSO
- Latching relay
- Non-latching Relay
- Selection Relay
- Current Sensor
- Resistor Buffer Card
- LCPSO
- Monoshot
- Switching Relay
- Reset card
- Isolation Amplifier
- TM-TC card

- Multiple sessions with the vendor for technical understanding of TTCP equipment for Telemetry and Telecommand operations completed
- Simulator-in-loop test with TTCP for telemetry acquisition demonstration completed

Checkout Hardware

- Reviews with the vendor for Power Rack harnessing activities completed
- Mounting of Equipment for Power Rack Completed
- Discussions with the vendor for Command Rack layout and harness routing plan in progress

Checkout Software

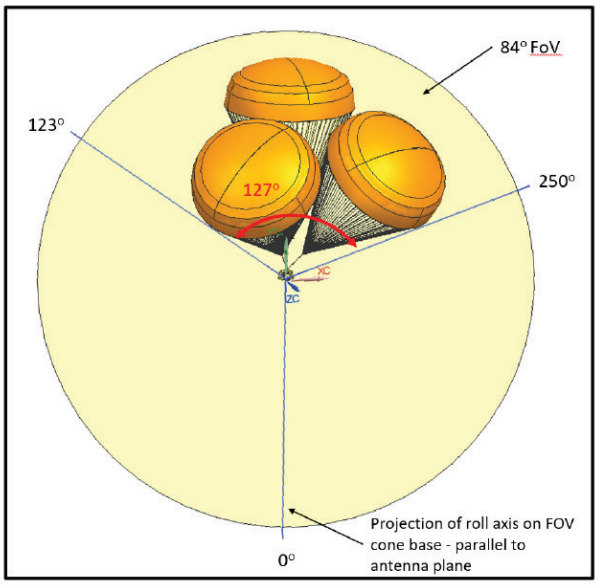
- Design of UI module with System Admin features for software health management
- Understanding of checkout software requirements for TTCP management & control
- Designer-level Testing and Bug fixing of the Parameter Module, Network Module

G1 Mission Activities

- Following sub-system accommodation in the G1–CM 3D model was carried out:
  - Deceleration system
  - Propulsion system
  - Thermal protection system
  - Separation interface
  - Up-righting system

- Avionics system (Total packages – 181 Nos)
- Recovery aids
- Crew Seat
- Half Humanoid
- Reduced ECLSS

- The Heat Pipe Layout for the bottom deck was released.
- ILDs for the following have been realized and ready for release:
  - Bottom deck
  - Bus-1 deck
  - Bus-2 deck
  - Bus-3 deck
  - SARB deck
  - 3 No's of Apex decks
- Fabrication Drawings of Side decks, Apex decks, Annular decks and Aft conical decks have been completed and approved by HPDD (VSSC) for CC release.
- Fabrication drawing of radial stiffener for bottom deck and one annular deck has been put on hold by HPDD (VSSC) for further analysis. Bottom deck fabrication drawing in discussion with URSC.
- Four Nos of side deck layout approved by all agencies concerned and same in the process of release. The bottom deck and apex deck are in progress. DGL deck pending discussion.
- G1-Cut-outs on conical panel note is released. The antenna backup plate and mounting plate are configured and the is shared with the structures team for inclusion in the panel fabrication drawing.
- FoV blockage of CM SPS antenna with drogue and main parachute; L1 band transfer antenna with grid fins were studied and shared with the mission team for further analysis.
- IDRSS deck layout was worked out and shared with thermal, AIT and RF teams for final clearances.



FoV blockage of CM SPS Antenna due to Main parachute

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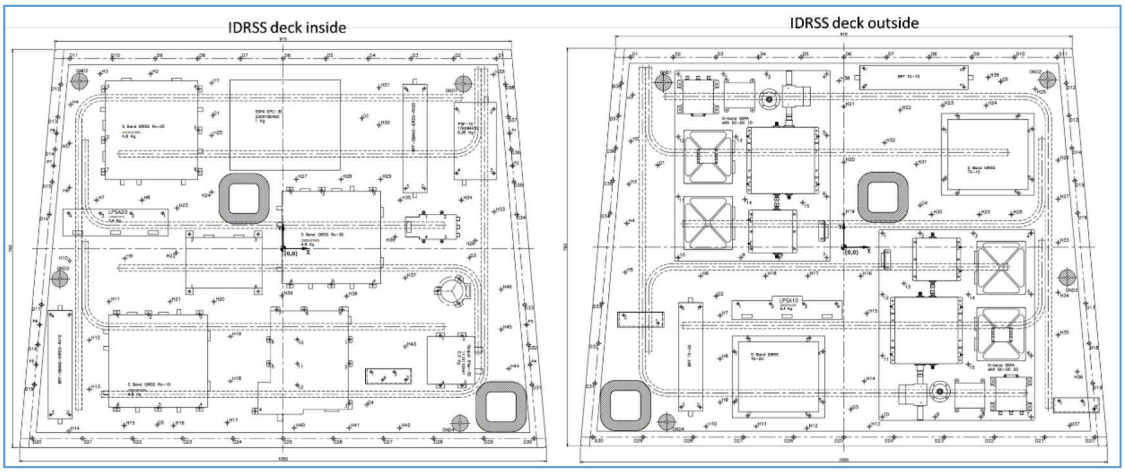
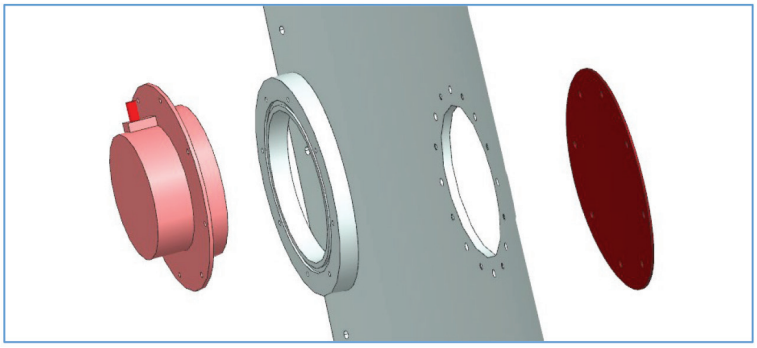


IDRSS deck layout with packages, heat pipe and harness tie mounts

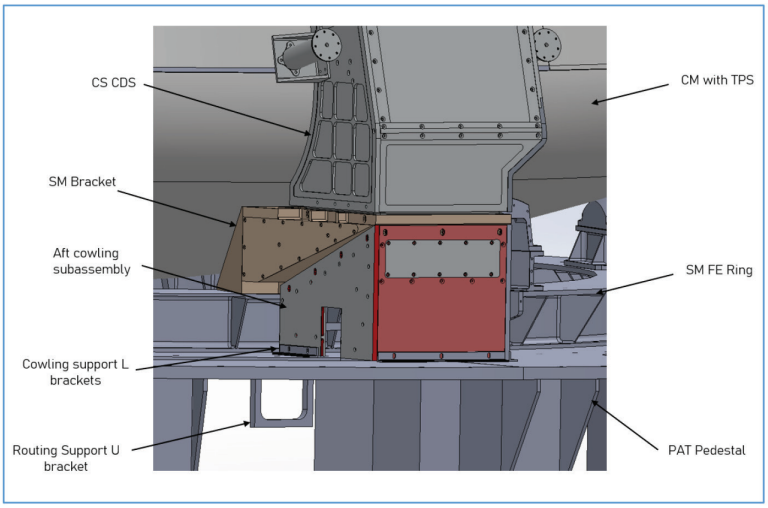
- G1- Cut-outs on conical panel note is released. The antenna backup plate and mounting plate have been configured and the is shared with the structures team for inclusion in the panel fabrication drawing.



S-band audio video antenna, antenna backup plate, conical panel and GFRP panel

PAT Mission Activities

- The following Baseline documents are ready and signed.
  - Avionics Package list
  - Umbilical Scheme
  - Electrical Architecture
  - Powering scheme
  - Pyro scheme
  - Grounding scheme

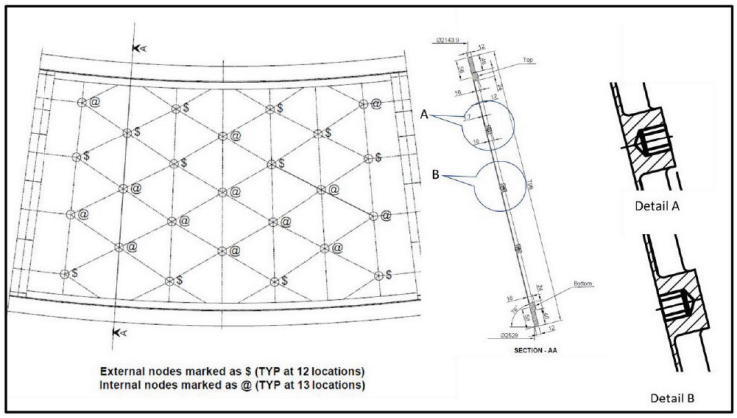


CS-CDS - assembly - PAT mission

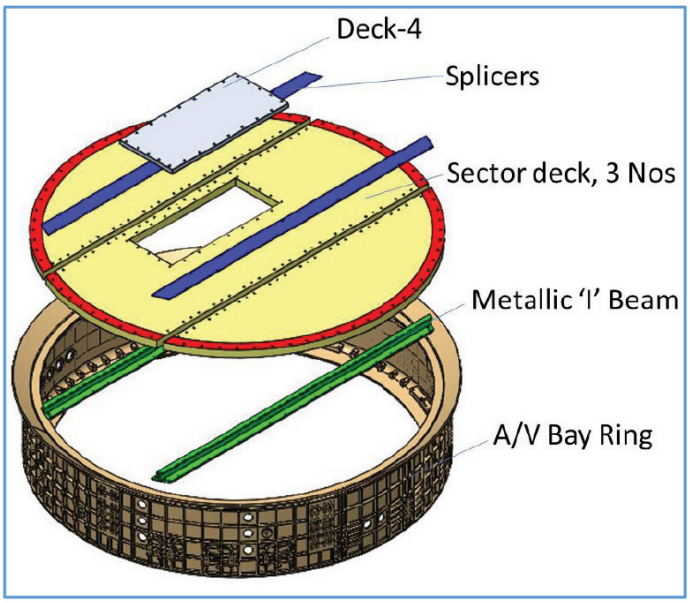
- Harnessing activities for PAT mission Inaugurated by Director HSFC.
- The Aft Cowling configuration in CS CDS assembly is finalized for PAT mission ensuring accommodation of the Crew Module on PAT Pedestal.

H1 Mission Activities

- Interface requirements on the Avionics Bay ring, forward conical region, aft annular region, Apex base ring and avionics bay dome were worked out and presented in AD VSSC review.
- Technical Note on Interface requirements for the accommodation of Avionics and ECLSS sub-systems in CMIS for H1-CM (draft version) was prepared and shared with SDED, STR Entity, and VSSC for generation of updated design drawings. This note describes in detail the interface requirements as well as cut-out requirements in CMIS.
- Configuration of mounting interface for various sub-systems (Avionics, ECLSS etc.) was carried out.
- Technical Note on Interface requirements for the accommodation of Avionics and ECLSS sub-systems in CMIS for H1-CM (draft version) was prepared and shared with SDED, STR Entity, and VSSC for generation of updated design drawings. This note describes in detail the interface requirements as well as cut-out requirements in CMIS.
- Provisional design drawings of the Apex base ring (shared by SDED, VSSC), Forward conical panel, Aft



Forward cone with details of internal/external nodes (typical at 3 locations)



Bottom deck mounting configuration on Avionics Bay ring

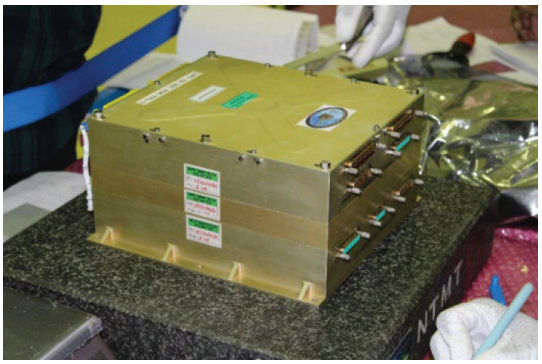
conical panel and Avionics Bay ring were verified for the availability of all interfaces as per 'Technical Note on Interface requirements for the accommodation of Avionics and ECLSS sub-systems in CMIS for H1-CM'

- ASF Connector-
  - Qualification tests completed & were presented to TT-ECQ team.

Quality Control Activities

- Screening of flight connectors completed
  - CHES clearance related activities:
    * Tool, Locator and shield soldering Inspection with respect to harness fabrication log book verified
    * All the harness details (8 Nos) verified
    * Harness fabrication log book verified
    * CC released face plate drawing verified
    * CC released bottom deck sector-1, 2,3,4,5,6, drawing verified
    * All the change proposals verified
    * NC connectors verified
- Audit of production files, crimping logs, and production log books verified
- Harness visual inspection observations are completed and observations are noted
- Activities at VSSC:
  - All fight sensor locations verified on crew module structure with respect to CC released mechanical drawings
  - Strain gauge bonding is completed on the Apex cylinder in PRU RH and PRU LH compartment (4 nos.) and the same verified
  - Strain gauge sensor bonding completed on aft bottom dome (13 nos.) and same verified
- Inspection and testing were completed for 22 nos. of Y-extenders & 9 nos. of one-to-one extenders
- All 5 nos. of checkout rack inspected & cleared for BURN-IN test
- 36 Hrs. BURN-IN test of the checkout system was monitored and observations recorded
- Isolation checks of pyro simulator extenders by mating to pyro simulator panel performed & cleared

- Pre-delivery inspection was carried out at the vendor's work centre for 50 Nos. of Deck Interface plate
- Interim Clearance Reports were generated for CM-CES Type 1 and Type 6 brackets, and NavIC antenna mounting brackets for Surface treatment operation
- Interim Clearance Report was generated for SCM Aft Heat Shield for TPS bonding activity
- Subsystem Inspection Procedure checks (SIP) were carried out for 61 Nos. of packages
- Non-conformance reports were generated for the following:
  - 26 NCs observed during Interface generation activities carried out at ICF, TERLS, VSSC.
  - Battery package mounting pitch mismatch in Battery deck.



SIP checks being carries out on a Type-1 package

- Online QC was carried out during the following activities for TV-D1-CM at AITF-2, ISITE and ICF, TERLS.
  - Interface generation activities on CM by ASTRE
  - CM reception at ISITE
  - Handling of CM using Crane and LLP
  - Harness tie mounts final assembly on CM
  - Trial assembly of secondary brackets with CM
  - Trial assembly of SAC deliverable antenna on antenna mounting brackets
  - Trial assembly of Flight packages on metallic sector decks
  - Trial assembly of Metallic sector decks with Deck interface plate and Honeycomb decks inside CM structure
  - Trial Positioning of Apex Cover (without CFRP panels) with the CM structure
  - Movement of CM within Air lock, Harness Lab and Cleanroom
  - Other trial/ final assembly operations as mentioned in the TV-D1 activities section
- QC check was carried out for the following drawings and documents:
  - Bottom deck assembly R1
  - Annular deck assembly R1
  - Deck interface plate

- Structure interface drawings R2
- Apex cover ballast mass drawings
- TV-D1 ballast mass drawings
- Ballast mass support plate drawings
- Central dome support plate drawing
- Heat flux sensor bracket drawing
- Heat flux cork spacer drawing
- Acoustic sensor TPS plug drawing
- Interface generation battery deck LH bracket
- Interface generation in TV-D1 Apex cover
- Interface generation on SM FE ring

- LSC meeting was conducted and NCs/ SNAGs were cleared for the following:
  - 26 NCs observed during Interface generation activities carried out at ICF, TERLS, VSSC
  - Battery package mounting pitch mismatch in Battery deck
  - SNAGs in Mini AINS RH and LH Brackets, Go-Pro camera mounting brackets 1 and 2, AVIS Camera mounting brackets 1 and 2, and Termination brackets 1, 4, 5, 7, 9, 10, 11, 12, 13 and 14
- A total 190 nos QC clearance reports released by QC team

Recovery Activities

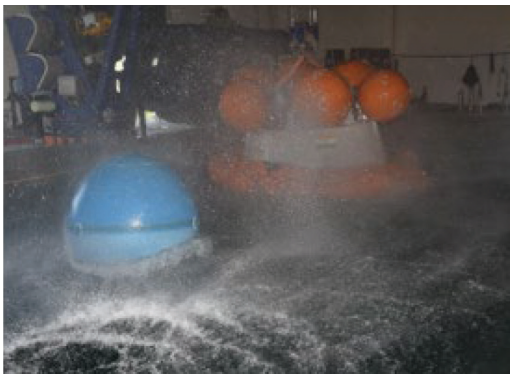
- CMRM-02 (Crew Module Recovery Model) realized at industry

Handing over of Crew Module Recovery Module

- Multiple meetings of ICRO were conducted with members from the Indian Navy, Indian Army, IAF, ICG, NIOT & SCI for recovery operations.

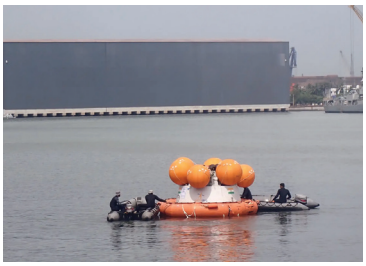
- Detailed deliberations were carried out on communication requirements, establishment of communications network, communication equipment on recovery ships and Ship-Borne-Terminal (SBT) for tracking.

- Gaganyaan Recovery Training Plan was released at the Water Survival Training Facility (WSTF) at INS Garuda, Kochi on May 24, 2023
  - The document highlights the training plan for the recovery of the crew module for the mission. It defines overall requirements with respect to the training of various teams participating in Recovery operations viz. MARCOs, Para jumpers, medical specialists, technicians etc.
- Phase-1 Recovery Training for TV-D1 CM was completed in June 2023 at WSTF, Kochi.



Successful completion of Phase-1 TV-D1 CM Recovery training at WSTF, Kochi by ISRO & Indian Navy

- Phase 2 of TV-D1 CM Recovery Training was completed in July 2023 at Vishakhapatnam with ISRO and Indian Navy.



Successful completion of Harbour trials for TV-D1 CM recovery training at Vishakhapatnam by ISRO and Indian Navy

- The final Phase of TV-D1 CM recovery training was completed in August 2023 with ISRO & Indian Navy teams. Harbour trials were performed with the CM Recovery Model (CMRM) and was towed using INS Shakti in Vishakhapatnam.

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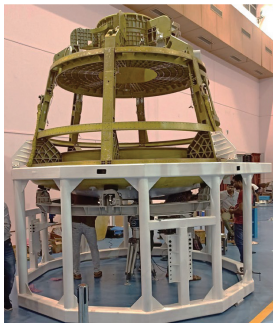
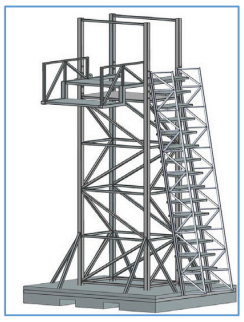
Harbour Trials for TV D1 CM Recovery with Indian Navy at Vishakhapatnam

MGSE Activities

- Assembly sequence for CM Acoustic and vibration test configurations at respective facilities and readiness of MGSE was presented to the Dynamic test committee.
- Load testing was carried out for MPIF and Bottom deck adapter.
- MPIF, CM Trolley, CM IF Ring, CES integration IF ring and CM handling brackets were loaded and transported to ICF/VSSC for TV-D1 CM Integration activities.
- Trial assembly was carried out for the following systems
  - Radial support brackets with CM and MPIF
  - SM FE Ring with MPIF
  - Aft Heatshield dome with MPIF
- Flight assembly of SM FE Ring with CM was carried out using MPIF and the required alignment was achieved.
- An Arming platform is configured for accessing the annular space between CM and CMF for the arming operation on FLP was presented to DRT-MGSE and all the actions were implemented.

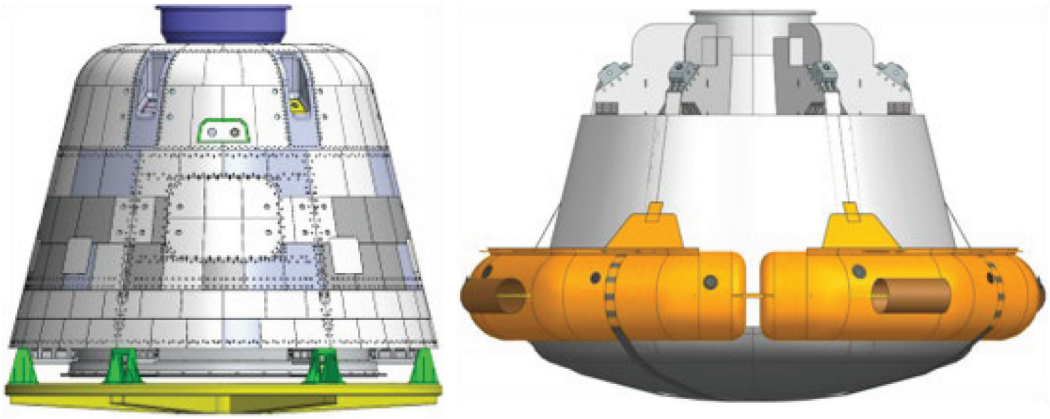


Flight assembly of SM FE Ring with CM using MPIF



Arming Platform Configuration

- An Adapter was configured to facilitate CGMI properties measurement of the Crew



Crew Module with adapter for CGMI measurements, CM with Toroidal buoy

Module without Aft Heatshield dome.

- 9 Nos. of Operation Procedure documents for MGSE assembly were prepared listed as below and reviewed by an internal team.
  - Aft Dome support bracket assembly with Aft Heatshield
  - Aft Dome support bracket assembly with SCM
  - CM Bare structure support brackets assembly with SCM
  - CM Crane Handling fixture assembly with SCM
  - Conical Panel assembly with Handling brackets and support fixture
  - MPIF and Aft Heatshield dome assembly
  - MPIF and Radial support brackets assembly
  - MPIF and SMA assembly
  - Swivel Hoist assembly with SCM

6. Safety, Reliability & Quality

1. Human Rating Certification

A robust Human Rating Certification mechanism is established and the system is in place. Two meetings of the National Advisory Panel (NAP) for Human Rating Certification were conducted to review and streamline the certification activities being carried out for Gaganyaan. The human rating certification plan was endorsed and approved by the NAP.

Parachute being a critical system, an audit was carried out at ADRDE, Agra to ensure the fabrication of the parachute meets the requirement and suggested following the QA augmentation during various phases of fabrication from yarn to packaging of the parachute.

A methodology has been developed to estimate the initial value of the risk threshold for Gaganyaan from lift-off to recovery of the astronaut.

2. Probabilistic Risk Assessment (PRA)

Equipped all ISRO centres to carry out PRA studies for the Gaganyaan mission and gave hands-on training to engineers at VSSC, LPSC and SDSC to perform the PRA.

A framework has been generated to integrate the PRA studies across ISRO centres to estimate the probability of end-state at the Gaganyaan mission level. Accident scenarios from lift-off to reaching orbit were identified and captured in event trees. Identified 88 unique fault trees to be integrated into the framework.

A strategy was developed to estimate the reliability of space systems and components using the limited data based on the Bayesian approach which in turn gives the input to the PRA studies.

3. Quality Assurance activities

TV-D1 Crew Module (CM) mechanical integration

QA teams were built, with fresh engineers, and equipped to carry out the QA activities. The following QA activities have been carried out for the successful flight of TVD1 mission.

- QA surveillance during the interface generation, assembly of secondary structures, avionics packages, flight sensors, CG measurement activities and torque verification pre and post-acoustic and vibration tests.
- Ensured all the hardware and the system had undergone the review process non-conformances observed were addressed in NCRB and recommendations were implemented.
- All requirements and procedures for Crew Module Integration activities are complied with. Quality Assessment Report (QAR) issued and cleared for TV-D1 launch.
- Verified the correctness of mass property data (CG, MI and PI) in the mass property of the TV-D1 CM document with respect to the 3D model.

TVD1 CM electrical integration and checkout

- Verification of baseline documents for the TV-D1 crew module including FMR, ATS gain

scheduling and channel allocation, avionics package list, powering scheme, grounding scheme, and pyro circuits. Verification of harness details and electrical integration of TV-D1 crew module with respect to baseline documents. Verification of checklists (integration and Checkout-T&E). Verification for data consistency before CC release of all electrical integration and checkout documents.

- Auditing of QC reports of electrical integration tools and testing devices. Participation in testing of the checkout system, auditing of results and ratification. QA surveillance during various phases of checks and countdown time. NGC chain and Instrumentation chain data analysis at each phase of testing and appraisal to appropriate review forums. Strengthening QC process in checkout data file update procedure.

Integrated Air Drop Test (IADT) Crew Module fabrication

Two IADT hardware have been fabricated to carry out the deceleration system qualification test. Quality assessment was provided for raw materials, fabrication drawings and process plan. Issued Raw Material Certificate and Test Certificate for the material. Ensured the fabrication adhered to approved process plans, based on CC released fabrication drawings. The inspection was carried out at identified stages at the component, sub-assembly and assembly levels. Deviations observed were discussed in LSC/NCRB and ensured the recommendations are implemented. Quality Assessment Report released and cleared for further use.

Crew Training Simulators (CTS)

Released Quality Assurance plan for Crew Training Simulator and Software. Fabrication drawing and process plan reviewed and cleared. Reviewed the Dimensional Inspection Report at the component/sub-assembly and assembly level. Identified Functionally Critical Dimensions w.r.t Crew access for various systems. Inspection was carried out at various stages of fabrication and appraised to the review forums.

Environmental Control and Life Support Systems (ECLSS)

Testing and qualification of various ECLSS Components. Pre-Dispatch Inspection for raw materials and review of process plans for fabrication.

Human Centric Products

- **Crew Seat Assembly (CSA):** Provided Test Certificate for raw material for Pallet and rigid links in CSA.
- **Active Dosimeter:** Participation in vibration and hot-cold temperature tests and audited the test results.

- QA participation in the storage of procured spacesuits in storage cabinets.
- CM-CES scaffolding load testing and inspection

4. Publication

- A paper on "Evaluation of intermodulation products and auto-allotment of carrier frequency in space missions" was selected for poster presentation at SMOPS-2023.
- A paper titled "Strategy for Developing Prior and Likelihood Functions to Estimate the Reliability of Space Systems using a Bayesian Approach" got accepted at ICRESH-2024 for publication.

5. Internal Reports

Quality Assessment Report: 09
Quality Assurance Note: 62

7. Biomedical Research, Crew Administration and Training

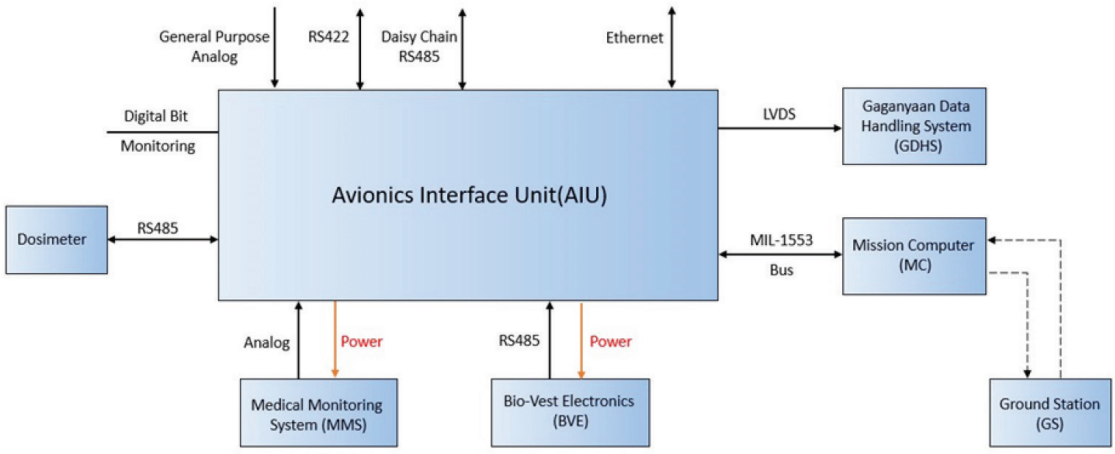
I. Biomedical Engineering

1. Biomedical Instrumentation

a. Avionics Interface Unit

System & functional requirements worked out for the Avionics Interface Unit for analogue and digital payload data acquisition and subsequent communication to Mission Computer as well as the Gaganyaan Data Handling System.

Interface & FPGA schematics, Isolation and power management schemes worked out and Components selected.



b. Human Centric Products

NDA with NID formed for the development of various Human Centric Products.

Prototyping of vomit bag and water sipper with lock mechanism done. Functional requirement generated and shared with NID.

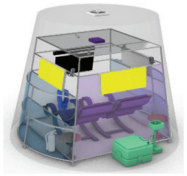
Vomit bag

Water dispenser

Collaborated with IIT Madras for the delivery of an Anthropometric measurement system and associated software for anthropometric data collection and analysis.

c. Space Analog Testbed

Design of a space analogous testbed to study the effects of various spaceflight stressors on human physiology and psychology in controlled and simulated conditions.



Test bed

2. Radiation Studies

a. Passive Dosimetry

Worked out the characterization plan for the passive dosimetry kit for Gaganyaan w.r.t. space-relevant radiation at NASA's Space Radiation Lab, BNL. Proposal submitted and accepted by NSRL.

Passive dosimeter

b. Active Dosimetry

System design of a semiconductor-based charged particle detector. Substrate & sensor selection, sub-system parameters, block diagram and signal flow worked out. Engineer model design in progress.

Reviewed the outcome of repeat qualification tests of DLJ's active dosimeter and contributed to the analysis of failures observed during the same.

Active dosimeter

c. Radiation Biology

Started collaborative projects with researchers from IISc, IIT-BHU and IIST to study specific effects of space radiation on biological organisms.

3. Flight Suit Testing & Development

a. Flight Suit Storage & Test Facility

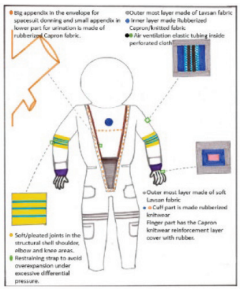
Designed cleanroom and pneumatic test rig for periodic testing of SOKOL KV2 suits. The pneumatic test rig is augmented for simulator training as well. Augmented the storage facility for high-pressure gas storage.

Suit Storage

b. Field Training Suit and IVA Suit

Worked out the system & functional requirements for the development of field training suit to be used during sea survival and launch complex training and training.

IVA suit design and development are being worked on in collaboration with NID.



FTS stitching scheme

c. Thermo-regulation Studies

Developed a 16-node model for studying the thermos-regulation of the anatomical human chest and subsequently optimizing the ventilation system of the indigenous flight suit.

II. Crew Training

a. Integrated training Repository Software

Developed and deployed software for management and archival of classroom training, physical training, evaluation & feedback and training resources.

b. Classroom Training & Physical Fitness

Second semester of classroom training on various Gaganyaan subsystems and mission plan completed. Regular Physical Training and swimming sessions are being conducted in conjunction with medical checks.

c. Nutrition & Diet

Astronaut kitchen infrastructure set-up completed. A meticulous nutrition plan worked out in conjunction with the National Institute of Nutrition and to cater to the planned diet.

ATF Kitchen

d. Flight Procedures

Drafted the Astronaut Reference Note for Medical procedures in consultation with IAM covering SOPs, medical kit contents & layout, usage of medicines and surgical items and medical waste disposal.

Worked out the guidelines for writing Flight Procedure Documents.

Worked on FPDs for ECLSS operations, crew flight plan and ARN on communication in conjunction with respective teams.

III. Sea Survival Training

Analyzed various post-touchdown contingency scenarios and subsequently devised a training plan. Assessed each test case w.r.t. the hazard analysis matrix to finalize the protocols for sea survival training.

2.7 Technical Facility / Infrastructure

The significance of establishing new facilities and enhancing infrastructure at various ISRO centers aligns with programmatic needs, long-term goals, Atmanirbhar Bharat, and reforms in the space sector.

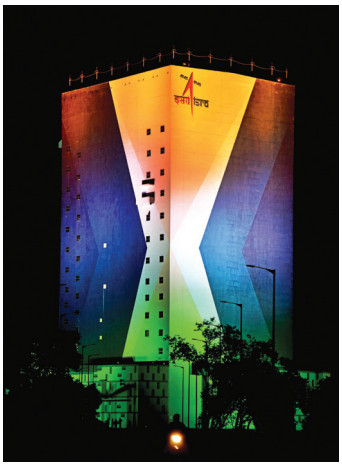
This section provides a detailed overview of the facilities and infrastructure set up at different centers.

LPSC

PS4 Stage Integration Facility is established at M/s. BATL, Thiruvanthapuram. The facility has the capacity to integrate six stages per annum. The infrastructure established includes a pre-assembly building, clean room, water calibration facility, instrumentation building, and bonded stores. The first stage is planned to be delivered in 2024.

SDSC-SHAR

PSLV Integration Facilities (PIF) is established to serve as Integration building for vehicle integration upto fourth stage, service building for MLP refurbishment works after launch, Mobile Launch Pedestals (MLP), bogie System with rail track & hauler for bogie (SPU) and check out systems & Pneumatic systems for electrical & leak checks. Currently, all the major facilities and systems are realized and commissioned. PSLV C55 & C56 were integrated upto the PS2 stage, moved to FLP, and launched successfully from FLP. PSLV-C58 launch vehicle stacking activities commenced at PIF in November 2023.



PIF

PSLV Integration Facilities (PIF) – Aerial View

First launch vehicle integration at PIF

SSLV Launch Complex (SLC)

An exclusive SSLV Launch complex (SLC) is being established at the Madhavankurichi area, Tuticorin district, Tamil Nadu. The existing launch pads at SDSC SHAR are lined up to meet launch demands of PSLV, GSLV & LVM-3 launches. SSLV Launch Complex is proposed to be realized for serving the polar missions for SSLV and launch vehicles by non-government entities thereby reducing their occupancy period in SDSC SHAR facilities for ongoing launch manifest. The location of the site is such that the azimuth corridor and permissible trajectory for SSLV is advantageous for polar missions as compared to SDSC SHAR. The launch complex consists of facilities for post-transport NDT, preparation of sub-assemblies & spacecraft, integration, launch, range systems for tracking, telemetry & telecommand and stage servicing, meteorology, material handling & safety systems. Currently, the revised project report cleared by SPAC.

Gaganyaan Launch Complex & Recovery Systems (GLCRS)

The Gaganyaan Launch Complex & Recovery Systems project is planned at SDSC SHAR to enable Human Space Missions from the Second Launch Pad (SLP) and realization of associated Crew facilities. As part of qualification tests under the Gaganyaan programme Ground Resonance Test (GRT) and Test Vehicle (TV-D1) launch are completed. All existing ground systems are being augmented to meet the HLVM3-G1 mission. For the Pad Abort Test (PAT-02), the new Launch Pedestal, Service tower modification, Electrical & Checkout systems augmentation at SRC are completed. TVP-D1 mission successfully accomplished on October 21, 2023. Crew Module recovered by Indian Navy and received at Chennai port on October 21, 2023. The crew Module is moved to SHAR for inspection and then moved to HSFC. Bubble lift modification completed, realization of Crew Access Arm (CAA) & modifications in Propellant & Pneumatic servicing system in progress.

Gaganyaan Control Facility

HSFC

ECLSS facility

A Building for ECLSS (Environmental Control and Life Support System) test facility under Gaganyaan Project is being established at ISRO land, Devanahalli. Structure work for the

low bay area is completed including a clean room. High bay structure work is in progress. Electrical works are progressing in parallel to civil. The arrival of materials at the site started. AHU design is cleared and the order is placed. The final drawing is finalized and material clearance is given.

ECLSS Facility at Devanahalli

NRSC

Construction of S/ka Antenna Terminal Building at DIPAC, Delhi with RCC framed structure founded on a deep foundation (Pile foundation) having a plinth area of 95 m^2 is completed.

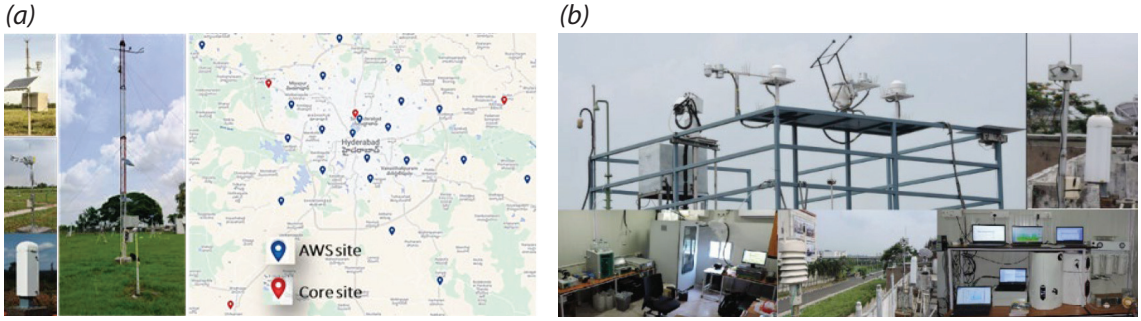
DIPAC

NARL

NARL has established two Camp Observatories, one in Hyderabad and the other in Kolkata, to address issues of national importance. The Hyderabad Camp Observatory (HCO) aims to study the impact of rapid urbanization on land-atmospheric interactions, dynamics of the atmospheric boundary layer, urban heat island, cloud physics, and changing precipitation patterns through observations and modeling. A network of instruments comprising of flux towers, net radiometers, ceilometers, disdrometers, soil temperature, and moisture probes, and 25 units of Automatic Weather Stations spread over Greater Hyderabad has been set up for this purpose. The Kolkata Camp Observatory (KCO) is primarily intended to investigate the vertical transport of aerosol and pollutants by deep convection and their effects on cloud systems and climate using a multisensor approach and modeling. The

KCO comprises a suite of instruments measuring the vertical distribution of aerosols and trace gases, including radiation measurements at the surface. Both the observatories have started functioning and the observational data are being analyzed for the said objectives and publication in refereed journals.

(a) (b)



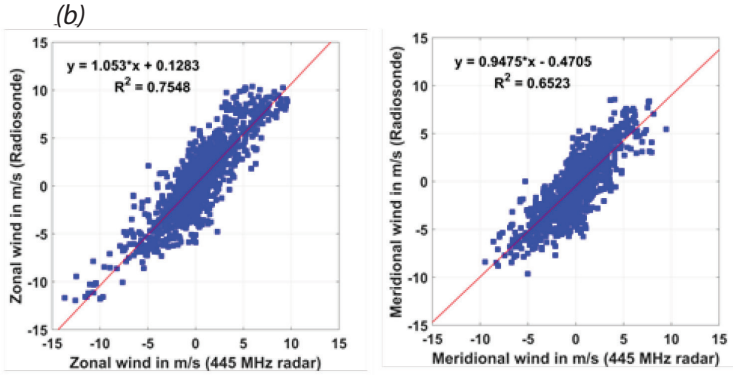
(a) Instruments installed at the core and AWS sites in and around Hyderabad. (b) Instruments installed at the RRSC campus, Kolkata

Design and Development of 445 MHz Spaced-Antenna wind profiling radar

NARL has designed and developed, with the help of Industry, a 445 MHz wind profiling radar that is capable of measuring atmospheric winds and turbulence up to 12 km. The radar is designed to function in Spaced-Antenna mode which makes it cost-effective and the first such wind profiling radar in the country. The radar comprises an antenna array,

(a)

(b)



(a) Photograph of the radar (b) scatterplot comparing winds observed by 445 MHz radar and GPS radiosonde for 28 flights during March - June 2023.

4 transmitters each of 2 kW (total peak power – 8 kW), 4 receivers, a radar controller, and a signal processing unit. The antenna array, comprising 252 microstrip patch elements, is arranged in 7 subgroups. Three of the outer subgroups arranged in an equilateral triangle and the center group is presently being used for Spaced-Antenna analysis. The atmospheric backscattered signals collected by 4 receivers are processed using an in-house-developed full correlation analysis (FCA) algorithm for estimating winds and turbulence in the height region of 112 m – 12 km with a height resolution of 37.5 m. The estimated winds have been validated with independent measurements of winds by radiosonde, which show good agreement.

PRL

1PF High-Performance Computing Facility– Param Vikram-1000 installed at PRL

To cater to the high-end computing requirement of PRL's scientific & technical fraternity, the CNIT team along with the HPC committee has upgraded the existing 100TF cluster resources to 1PF HPC. The new 1PF HPC facility at PRL has been inaugurated on Thursday, June 22, 2023. The facility has been named as "PARAM VIKRAM -1000".

The PARAM VIKRAM-1000 HPC facility has 108 computing nodes and dispenses 7296 CPU cores, 2,76,480 GPU Cores, 74 TB of RAM, and 1 PB of high-performance parallel Lustre file system. The new HPC compute nodes are Made in India and the majority of the software used is open source. It provides a theoretical peak performance (Rpeak) of 1395.63 TeraFlop/s (TF) and a Maximal LINPACK performance (Rmax) of 956.34 TF. As of July 2023 supercomputer of India list, Param Vikram-1000 is 14th fastest supercomputer in India. C-DAC, Bengaluru maintains the list of the top supercomputer in India.

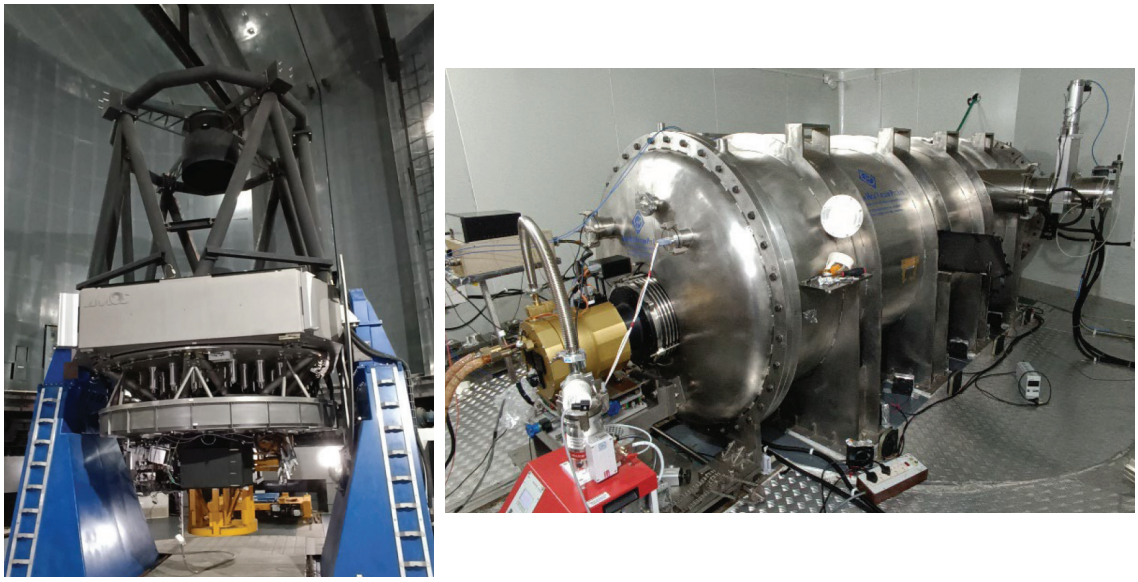
1PF High-Performance Computing Facility – Param Vikram-1000 installed at PRL

At present, it is extensively utilized for various scientific and research activities by PRL Scientific & Technical fraternity. During June to October 2023 period, 08 peer-reviewed

Scientific Papers were published in reputed Scientific Journals wherein the Param Vikram-1000 facility has been used for computations.

2.5 m Telescope at Mt. Abu Observatory fully commissioned

The PRL 2.5 m telescope project is a state-of-the-art technological development taken up at the Physical Research Laboratory (PRL) in collaboration with Advanced Mechanical and Optical Systems (AMOS), Belgium. The tracking accuracy of the telescope is between 0.2 and 0.5 arcsec RMS in a close loop with Auto guider unit. The telescope is commissioned and has been operationalized. The second generation PARAS-2 (PRL Advanced Radial Velocity All Sky Search-2) has also been commissioned with the new 2.5 m telescope. The PARAS-1 attached to the 1.2 m telescope enabled the discovery of three exoplanets from India. It is anticipated that the present upgraded PARAS-2 attached to a much higher resolution 2.5 m telescope will enable many newer and exciting discoveries.

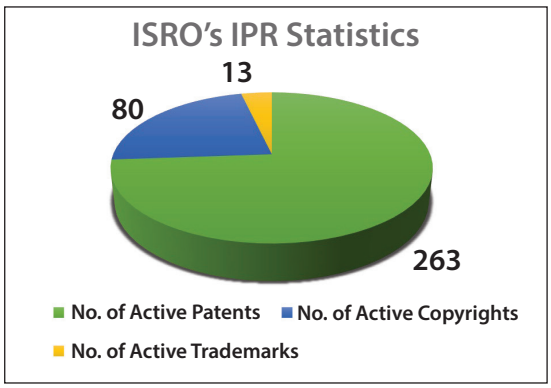


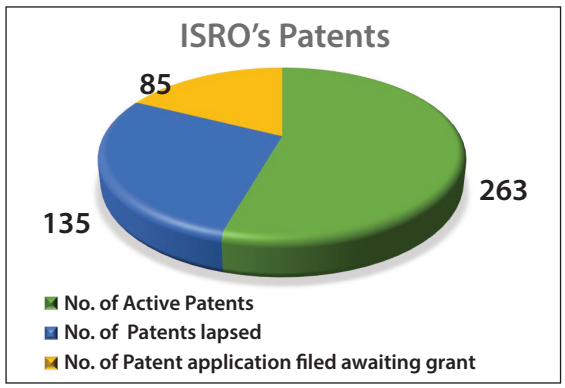
2.5 m telescope and PARAS-2

2.8 Capacity Building

1. Intellectual Property Rights

ISRO has 263 active patents, 80 nos. of copyrights, and 13 nos. of trademarks. During the reporting period around 25 patent applications and 5 copyright applications are filled, 40 fresh patents were granted and active patents were renewed. Presently, 85 nos. of patent applications are under various stages of examination and 15 undergoing drafting by the patent attorneys before their eventual filing at the patent office. The IPR portal has been developed to process the IPR proposal from ISRO centres online and also create IPR processing online and the same is made operational.





2. Industry Interface

2.1. International Astronautical Congress (IAC-2023)

International Astronautical Congress (IAC-2023) was organized at Baku, Azerbaijan during October 02–06, 2023. ISRO along with NSIL & IN-SPACe participated in various technical sessions, and bilateral discussions with international space agencies & industries and also established an exhibition pavilion by showcasing achievements and future plans of Indian space programmes. DOS also facilitated for participation of Indian space start-ups in the event. The Secretary, DOS / Chairman, ISRO, and senior officials of DOS participated in the event.

2.2. International Conference on Space 2023

ISRO participated along with NSIL & IN-SPACe in the International Conference on Space 2023, organised by the Confederation of Indian Industry (CII) during

September 14-15, 2023. More than 20 International space industries and 120 Indian space industries participated in the conference.

2.3. G20 Space Economy Leaders Meeting

Under India's G20 Presidency, the 4th edition of the Space Economy Leaders Meeting (SELM) was organized by the Indian Space Research Organisation (ISRO). This important event took place in Bengaluru during July 06-07, 2023, and witnessed the presence of esteemed heads and senior representatives from space agencies of 18 G20 countries, 8 invited countries, and 1 international organization. Moreover, 34 space industries from abroad and 53 Indian space industries actively participated, contributing to the event's grandeur.

2.4. India Mobile Congress (IMC)-2023

ISRO participated in the 7th edition of India Mobile Congress - 2023 organized by the Department of Telecommunication in association with the Cellular Operator Association of India (COAI) during October 27–29, 2023 at New Delhi. Space pavilion was established by showcasing ISRO's achievements, latest technologies, satellite applications, etc.,

3. Student Outreach Programmes

3.1. Yuva Vigyani Karyakram-2023 (YUVIKA-2023)

The Yuva Vigyani Karyakram - 2023 (YUVIKA-2023) is a two-week' student's residential sponsored programme organized during May 15-27, 2023 at 7 Centres of ISRO / DoS viz. VSSC

Thiruvananthapuram, SDSC Sriharikota, SAC Ahmedabad, URSC Bengaluru, NRSC Hyderabad, IIRS Dehradun, NE-SAC Shillong. Around 1 lakh students applied for the programme online, out of which 337 students from 36 States / UTs across the country were trained in Space Science and Technology. 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.

3.2. National Space Innovation Challenge (NSIC)

ISRO collaborated with the Atal Innovation Mission and organized the National Space Innovation Challenge (NSIC) from August 11-September 20, 2023 for 5th – 12th class students. NSIC is a National-level campaign designed to ignite next-generation space enthusiasts to understand and contribute towards the growing Indian space economy and future space workforce. As part of the programme students submitted a short research report on a solution across diverse topics like Space Junk Collection Robot, Reusable Rocket Design, Satellite Design, Indian Spaceship Design for Mars, etc.,

3.3. ISRO-MVA global video competition

ISRO in association with Moon Village Association (MVA) an NGO based in Vienna, conducted a global video competition as an outreach event for the Chandrayaan-3 launch. The competition was held for two age groups i.e. 13-17 years and 18-21 years during April 20-June 11, 2023. A total of 302 videos were received across the world, predominantly from India.

3.4. International Moon Day

As part of International Moon Day celebration, ISRO organized an online painting/drawing and Quiz competition for school students of class 8th to 12th standard from July 14-20, 2023.

3.5. Antriksh Jigyasa Portal

ISRO developed an Antriksh Jigyasa online STEM portal to provide e-learning on space science, space technology, and space applications. A total of 6 space varta, which a space science talks by eminent scientists has been conducted through the Antriksh Jigyasa portal.

3.6. Space on Wheels

ISRO signed an MoU with VIBHA during IISF-2022 at Bhopal in the presence of the Secretary, DOS for the movement of 6 nos. of Space on Wheels across the country. Accordingly, Space on Wheels has been moved to nook and corner of the country.

4. Human Resource Development

4.1. Annual Capacity Building Plan (ACBP)

DoS Annual Capacity Building Plan (ACBP) was prepared by ISRO in collaboration with the Capacity Building Commission (CBC) & STI-CB Cell of office of Principal Scientific Adviser (PSA). A detailed competency gap survey has been carried out among all technical cadres of ISRO / DoS and interventions have been planned to bridge the gap in domain, functional, and behavioral skill sets. The ACBP was released by Hon'ble Minister of State, Department of Space Dr. Jitendra Singh during August 2023 in the presence of Secretary, DOS.

4.2. ISRO Technical Training Programme (ITTP)

ISRO is conducting the ISRO Technical Training Programme in collaboration with the Ministry of Skill Development & Entrepreneurship (MSDE), Government of India. The programme is intended to impart skill development training to the technical staff of ISRO

at various technical facilities of eight National Skill Trainings Institutes (NSTIs) across the country under MSDE.

A total of 41 ITTP programmes have been planned in FY 2023-24 in these NSTIs with the aim of upskilling / re-skilling of 700 technical staff, out of which 17 programmes have already been completed with training of 280 staff.

4.3. Drivers Training Programme (DTP)

ISRO entered into an MoU with the Institute of Driving Training and Research (IDTR), Pune for reskill / upskilling of ISRO's transport staff. A total of eight programmes for 120 drivers is planned during the year and the same is under execution.

4.4. Capacity Building Programme on Geo-spatial Technologies and Applications (GSTA)

ISRO / Department of Space has launched a Capacity Building Programme on "Geospatial Technologies and Applications" in tandem with the objectives of National Geospatial Policy - 2022. The first phase of the capacity building programme on "Geo-spatial Technologies and Applications" has been inaugurated by Hon'ble Minister of State, Department of Space, Government of India, Dr. Jitendra Singh in the presence of Secretary, Department

of Space Sri S. Somanath, Chairman, Capacity Building Commission, Sri Adil Zainulbhai and other senior dignitaries.

58 Participants from twenty-nine Ministries/Departments /State Governments attended this one-week programme at RRSC – North, NRSC at New Delhi & NE-SAC, Shillong.

4.5. Emerging Technologies Workshop

A series of Emerging Technologies workshops covering Data Driven Decision Making (DDCM), Artificial Intelligence, Machine Learning, and Deep Learning has been conducted at Bengaluru, Hyderabad, and Ahmadabad in collaboration with Wadhwaani Institute of Technology and Policy (WITP), Capacity Building Commission and STI-CB Cell of office of PSA. A total of 129 Scientists / Engineers have been trained in this workshop.

4.6. Onboarding on i-Got platform

As part of Mission Karmayogi, ISRO has taken steps to onboard all its employees on i-GoT platform for capacity building and encouraging learning. At present, already more than 6000 ISRO Staff (Highest in comparison to any other S&T department) have registered on i-GoT platform. Onboarding of remaining ISRO staff will be also completed soon.

5. RESPOND

5.1. Introduction

One of the most significant initiatives of the CBPO (Capacity Building and Public Outreach) office at ISRO Headquarters is Academic Interface, which aims to establish knowledge/ incubation/research etc. centres across the nation and promote collaborative research with academia/labs/institutes. Acknowledging the necessity of expanding the academic link with institutions throughout the nation, several efforts aimed at building capacity have been implemented to enhance academia's involvement in ISRO activities. The aforementioned initiatives comprise R&D Projects (RESPOND Basket), Space Technology Cells (STCs), Regional Academic Centre for Space (RAC-S), Satish Dhawan Centre for Space Science (SDCSS) at Central University of Jammu, Centre of Excellence (CoE) at IISc, ISRO Chairs, and collaboration with the Centre for Nano Science & Engineering (CeNSE) at IISc.

2.8 Capacity Building

5.2. Sponsored Research

In order to encourage academics to take part in and contribute to a variety of space-related research initiatives, ISRO launched the RESPOND (Sponsored Research) project in the 1970s. The faculty of universities and other academic institutions take on initiatives under RESPOND that are pertinent to the Space Programme. This programme gives Indian academic institutions financial and technical support to carry out research and development projects pertaining to space science, space technology, and space applications. In order to support the Indian Space programme, the RESPOND initiative seeks to strengthen academic foundations, provide high-caliber people resources, and improve facilities at academic institutions. It is anticipated that the study investigations will focus on some of the upcoming space activities, which would be a beneficial addition to the many missions carried out by ISRO.

In order to conduct research in the fields of space technology and applications, ISRO has also established nine Space Technology Cells (STC) at prestigious universities, including Indian Institutes of Technology (IITs) in 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).

Six Regional Academic Centres for Space (RAC-S) have been established in regions of the country with the dual objectives of promoting space technology activities among students and conducting advanced research in areas relevant to the technological and programmatic needs of the Indian Space Programme. Regional Academic Centre for Space is located at MNIT Jaipur (Western region); at Gauhati University, Guwahati (North-Eastern region); at NIT Kurukshetra (Northern region); at NITK Surathkal (Southern region); at IIT (BHU) Varanasi (Central region) and for the Eastern region at NIT Patna. RACS provides the opportunity for the students and faculty to work in cutting-edge research topics and also encourages awareness creation and capacity building at the institute level.

Considering the requirements of ISRO in the fields of nanotechnology and nanoscience, ISRO has initiated a partnership with the Centre for Nano Science and Engineering (CeNSE) at IISc. In addition to training and capacity building, the centre also provides the state of the art nanofabrication and characterisation facilities for the R & D activities of ISRO.

A Centre of Excellence (CoE) on "Advanced Mechanics of Materials" has been established at IISc with the goal of pursuing advanced research in the fields of materials, particularly on non-classical continuum mechanics and geometric and data-driven models for space applications.

A centre called Satish Dhawan Centre for Space Science has been set up jointly by the Central University of Jammu, Jammu, and ISRO to address the growing needs of the region in terms of geospatial and other space technology applications. The primary focus is on research and development in the areas of space science, space-based disaster management, technologies for regional development, etc.

Support is also given under RESPOND to national and international conferences that are held by reputable colleges, institutions, agencies, and businesses on subjects of shared interest and are centered on space operations or related to the missions, programmes, and objectives of the ISRO.

5.3. Activities

During the period, RESPOND supported 83 New Projects, 31 ongoing projects, R & D activities of nine Space Technology Cells, and six Regional Academic Centre for Space. During the year, 32 sponsored projects have been completed. Scientific publications have emerged out of these projects apart from fulfilling the objectives.

During the year, 41 Universities/Colleges, 24 IITs /NITs, and 5 Research Institutes/ Laboratories were involved in R&D projects (Figure-1). Further, during the year, a large number of projects have been supported in the area of Space Technology (88) followed by Space Applications (19) and Space Science (7) (Figure-2).

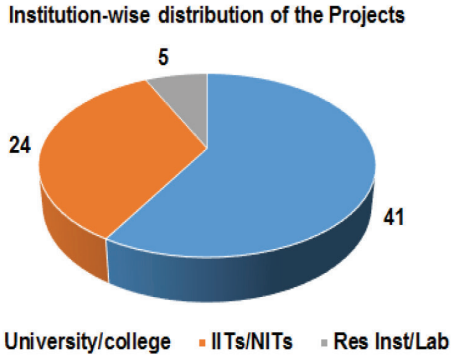


Fig (1)

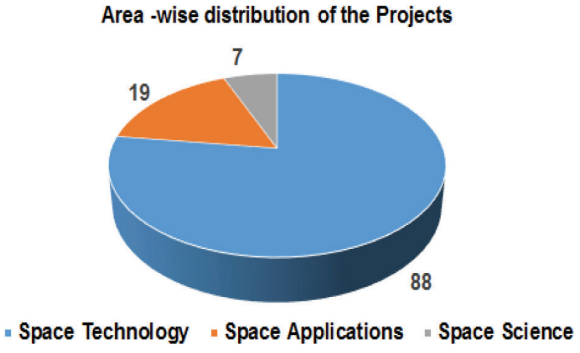


Fig (2)

5.4. 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

2.8 Capacity Building

Programme with Savitribai Phule Pune University (SPPU, Pune) to carry out research activities in the areas of space technology and applications.

During the period, 66 new projects and 103 ongoing projects pertaining to nine Space Technology Cells have been supported under the STC Programme. Under STCs, 77 projects have been 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	13	15	15
2.	IIT Bombay	5	17	18
3.	IIT Kanpur	17	1	18
4	IIT Kharagpur	7	21	10
5	IIT Madras	7	10	14
6	IIT Roorkee	6	21	0
7	IIT Guwahati	3	4	0
8	SPPU, Pune	3	6	2
9	IIT Delhi	5	8	0
	Total	**66**	**103**	**77**

5.5. Projects at Regional Academic Centre for Space (RAC-S)

Under Regional Academic Centre for Space programme a total of 22 New projects and 28 ongoing were supported during the year.

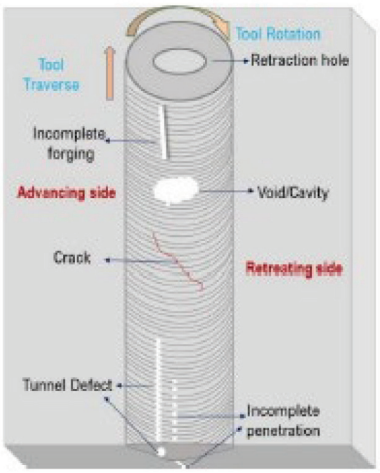
Sl No	Name of the RAC-S	No. of Projects	
		New	Ongoing
1.	MNIT, Jaipur	9	4
2.	NIT Kurukshetra	0	2
3.	Gauhati University	0	3
4	NITK Surathkal	5	6
5	IIT (BHU)	8	10
6	NIT Patna	0	3
	Total	22	28

The projects are reviewed by domain experts in ISRO and later by Joint Policy and Management Committees consisting of experts from ISRO and the academia.

5.6. Highlights of Some of the completed RESPOND Projects

5.6.1. Acoustic emission characterization of Friction Stir Welded joints in aluminium alloys AA2219 used for aerospace applications

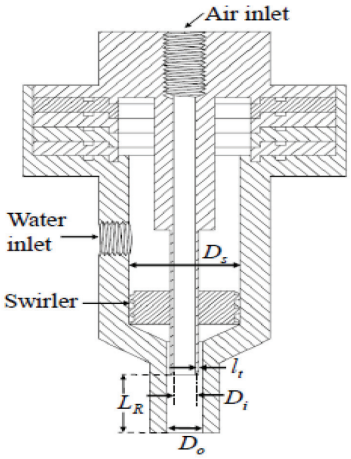
The project aimed towards Non-Destructive Evaluation (NDE) of friction stir welded joints in AA2219 alloy. The research work included identification and characterization of zones and defects in FSW through conventional NDT methods & AE data analysis; failure parameters /criteria using Acoustic emission technique; outcome in terms of feasibility of AET as an online health monitoring tool. The outcome of the project has got significance in the FSW joints of aluminum alloy 2219 used in structural components of Space vehicles.



Pictorial representation of FSW defects

5.6.2. Effect of acoustics on the characteristics of Swirl Coaxial Atomiser

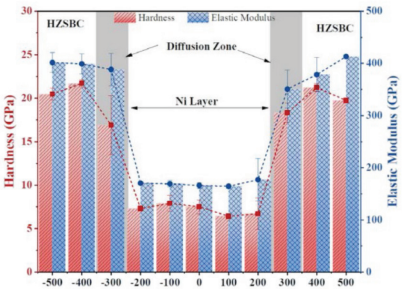
Under this project, a swirling, annular liquid flow surrounding a recessed gas flow is particularly examined. Such a configuration, Gas Centred Swirl Coaxial (GCSC) injector is often used in liquid rocket engines with staged combustion cycles. The project studied a complete characterization of swirl coaxial spray in the presence of acoustic forcing and its predictive methodology. Output of the studies are the inputs for the assessment of stability characteristics of semi cryogenic engine.



GCSC injector used in the experiment

5.6.3. Brazing of HfB2-ZrB2 based ultra-high temperature ceramics

Under this project, HfB2 and ZrB2, the potential ultra-high temperature ceramic (UHTCs) for thermal protection systems in re-entry vehicles were processed and characterized. The project thus has helped in promoting the utility of these materials as fourth generation re-usable leading edge nosecone material for re-entry space vehicles.



Hardness and elastic modulus variation of HZSBC brazed composites across the interface

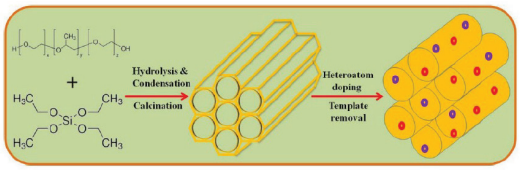
5.6.4. Two phase Mechanically Pumped Fluid Loop (MPFL) with microchannel based evaporator for application to high power communication spacecraft, interplanetary missions and human space missions

Under this project, experimental studies on heat transfer and pressure drop characteristics of MPFL for three different working fluids over the range of heat flux and mass flow rates was carried out. The project has delivered system level studies on prototype model of two phase MPFL and development of correlations between bubble dynamics and heat transfer performance of MPFL. The development of prototype MPFL has a crucial role in the design of the two phase mechanically pumped fluid loop proposed for flight experiments in the future space mission of ISRO.

Hardness and elastic modulus variation of HZSBC brazed composites across the interface

5.6.5. Meso–microporous core shell carbon based materials and electroactive diluent for long cycle life and high energy density Li-S batteries

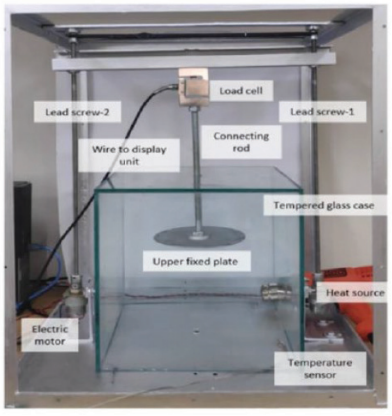
Under this project, technology development of Li-S pouch cell with delivering capacity of 500mAh and energy density of > 350 Wh/kg (VsSOA 150 Wh/kg) is achieved. The project has delivered process methodology know how and optimized sulphur cathode, functionalized Separator material composition as deliverables with improved electrochemical performance for application in Li-S Cells.



Schematic illustration of heteroatom doped mesoporous carbons

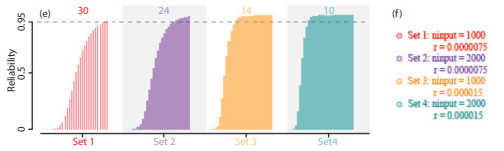
5.6.6. Design and development of a Proof of Concept model of a packaging methodology and Rigidization for Gossamer Space Antenna structures

The project developed a mathematical model of packaging methodology and rigidization for Gossamer Space Antenna Structures and their control. The outcome of the project will be used for the development of ultra-lightweight adaptive membrane structures, large-size multi-layer planar antennae and very light weight compact inflatable antennae.



5.6.7. Software Reliability modeling for LV onboard software

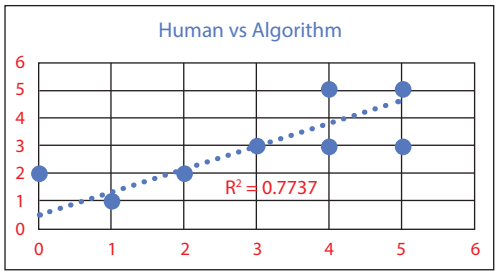
The project aimed at reliability modeling for LV onboard software. The project has delivered an executable model supported by a Graphical User Interface and user reference Manual. The model is planned to be adopted for LVM3 onboard software.



Simulated Data Summary

5.6.8. Assessment of utilization of VGI sources for flood inundation mapping in urban environments

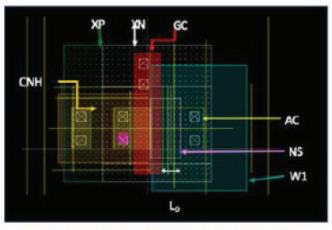
Under this project, an approach and algorithm have been developed for automatic semantic analysis and interpretation of multi-modal social media inputs acquired under different conditions to extract flow-related parameters especially in urban environments to aid the mapping of flood hot spots. This is a first-of-its-kind algorithm which will be useful for near real-time operations of flood management for integrating data from various sources.



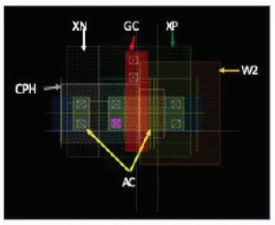
Validation of human interpretation vs Algorithm output

5.6.9. Development of high voltage (HV) devices for CCD clock drivers

The project aimed to develop and qualify a voltage-scalable HV device module for SCLs 180nm CMOS technology. The project has resulted in the first indigenously development of 7,10 V and 20V High voltage devices with integration into SCLs 180nm CMOS process. These devices are planned to be used for clock Drivers and various PMICs for CCD /CMOS imager applications.



Layout of a standard n-HV MOS device

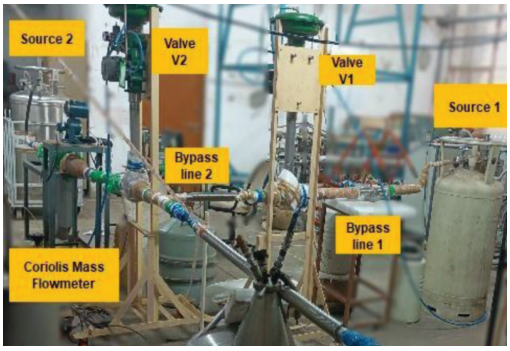


Layout of a standard p-HV MOS device

5.6.10. Theoretical and experimental studies on flow characteristics during the changeover of flow from start-up tank to main run tank during liquid rocket engine testing

Under this project, a numerical model based on the Finite Volume method is developed and

the optimum value sequence, which produces minimum pressure variation at the engine inlet is derived through detailed parametric analysis. Further cryogenic test facility is developed and a source changeover experiment is performed. The numerical model developed in FLOWNEX is validated with the in house experimental results. The methodology derived through extensive theoretical studies at IIT Kharagpur was extended to the real time source change over problems in LOX & Isrosene system in the SIET facility during commissioning activities.



Source Changeover Experimental Set Up

6. Space Technology Incubation Centres

Space Technology Incubation Centre (S-TIC) has been setup with an aim to attract and nurture the 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 the Academia–Industry ecosystem for Space Technology.

At present, six S-TICs 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). 6 Product / Prototype Development Projects varying from TRL-4 to TRL-8 have been completed at these S-TICs in FY 2023-24 and 37 projects are in progress.

As of the year 2022, S-TICs have created remarkable impact by providing on-hand 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.

Online pollution monitoring system developed by STIC NIT Agartala in mentorship of NESAC

Metamaterial based Antenna developed by STIC NIT Agartala in mentorship of NESAC

LC bandpass Filter for Space Technology

2.9 Quality Management, Occupational Health & Safety

Soft and safe landing of Chandrayaan-3 lander on the Moon, launching of a dedicated mission to study the Sun- Aditya L1, successful launch of the first major milestone for Gaganyaan Mission namely Test Vehicle D1 (TV D1) with Crew Escape System (CES) and Crew Module (CM), first successful Landing experiment of Re-usable Launch Vehicle and tasting success with GSLV F12 and SSLV D2 by building on the lessons of the previous unsuccessful attempts were the hallmarks of the year 2023 for ISRO.

The role of the quality and safety Systems of ISRO in assuring the Quality, Reliability and Safety aspects of all the above developmental missions as well as the other operational missions has been enormous. The culture of meticulous care that has been painstakingly built over the decades by ISRO has played a crucial role in leaving no stone unturned towards achieving the goal of mission success. The dedicated Quality and Safety teams across all Centres/Units of ISRO continued their sharp focus on each and every aspect of the missions and also the Directorate of Safety, Reliability, and Quality (DSRQ) at ISRO headquarters continued to interact with them on various critical aspects of Quality and Safety.

Significant quality and safety aspects of the various missions and the salient role played by the quality and safety teams are summarised below.

Quality Assurance of Chandrayaan-3

The saga of achievement of peak reliability for the Chandrayaan-3 mission can be aptly considered a case of engineering excellence. Several enhancements were pursued to increase the reliability of the various systems of Chandrayaan-3 based on the experience of Chandrayaan-2. Specific focus was given to the robustness of the design to handle a very wide range of dispersions and a failure mitigation-based approach, with an associated contingency recovery plan, was taken towards ensuring mission success under all possible system degradation/failure scenarios. Building on the heritage of Chandrayaan-2, specific modifications were done on the sensors, propulsion system, guidance and control systems, lander leg, and several other hardware and software systems for enhancing the performance margins. A large number of tests were conducted on the lander systems to demonstrate the effective performance of the systems on the ground, here on Earth, before the actual performance on the Moon, thereby resulting in mission success.

2.9 Quality Management, Occupational Health & Safety

Quality Assurance of Developmental Missions

Test Vehicle (TV D1)/ Crew Escape System (CES)/ Crew Module (CM)

First-of-its-kind developmental missions involve a great deal of ingenuity and anticipation of all possible failure scenarios towards ensuring mission success. Developmental missions also build on the experience gained from the previous operational missions as has been the case with Test Vehicle (TV D1) which took up the in-flight demonstration of the Crew Escape System (CES) and the various systems of the Crew Module (CM) as the first major milestone of ISRO's Gaganyaan mission. The TV D1 is built on the heritage of the L40 Systems employed in the GSLV Missions. All the changes in the heritage systems as well as the new systems were thoroughly assessed by the quality teams and enabled the development on a totally new Vehicle on a fast-track mode. Failure Mode Effects and Criticality Analysis (FMECA) and other reliability studies were also carefully carried out by the quality teams for this mission.

Aditya-L1 spacecraft – Dedicated mission to study the Sun

A major quality challenge in the development of the Aditya-L1 spacecraft was the contamination control towards safeguarding the sensitive optical systems as well as the mission planning to reach the designated point Lagrange Point L1. The quality teams also worked in tandem with the various external Indian agencies like the Indian Institute of Astrophysics (IIA) and the Inter-University Centre for Astronomy and Astrophysics (IUCAA) towards ensuring the quality of the respective systems. The Spacecraft is currently on its way to the L1 point which is about 15 lakh km away from Earth and the quality teams continue to keep a strict vigil on the various aspects of this journey.

Small Satellite Launch Vehicle (SSLV-D2)

The quality teams played a key role in the validation and acceptance of the changes in the separation systems and other software elements of SSLV-D2 compared to the previous launch attempt. This mission was built on the lessons learned from SSLV-D1 and was achieved flawlessly.

Re-usable Launch Vehicle-Landing Experiment (RLV-LEX)

Quality and reliability teams played a significant role in the testing, qualification, and acceptance of the various systems including the landing gear systems, navigation, guidance, and control systems towards the autonomous landing experiment of Re-usable Launch Vehicle. ISRO learned several lessons from this first-of-its-kind winged body, which is more akin to an airplane and is understandably different from Launch Vehicles or

Satellites. The RLV landed on a runway at the Aeronautical Test Range (ATR), Chitradurga, Karnataka, which is a clear advancement from the landing on sea accomplished during the previous mission (RLV-TD (Technology Demonstrator)).

Navigation Satellite (NVS-01)

Quality teams worked towards the qualification and acceptance of the indigenously developed atomic clock, a crucial element of this satellite. NVS-01 is the first of the second-generation satellites envisaged for the Navigation with Indian Constellation (NavIC).

Quality Assurance of Operational Missions

Sustaining and repeating successes for operational missions is a major challenge that is largely governed by the strength of the quality processes and systems. The quality aspects of the operational missions namely PSLV-C55, PSLV-C56, PSLV-C57, LVM3 M3, LVM3 M4, and EOS-07 were meticulously adhered to and satisfactorily complied. Improvements were carried out on the GSLV F12 launch vehicle based on the experience of the previous unsuccessful attempt and the launch was successful this time placing the NVS-01 satellite in its intended orbit.

Integrated Product Assurance Board (IPAB)

The culture of rigorous review is one of the key strengths of the Quality and Reliability systems of ISRO. The quality and reliability teams spread across the ISRO Centres and Units assess and assure the quality of the various systems and also participate in the several reviews that need to be carried out before committing a system for launch. Over and above this strong system, an all-encompassing board named the Integrated Product Assurance Board, constituted by the Chairman, ISRO/Secretary, DOS, independently reviews the quality aspects of the missions in an integrated manner. This board comprises the chief of quality and reliability of all ISRO Centres/Units and is headed by the Director of DSRQ of ISRO Headquarters. The IPAB independently assessed the quality and reliability aspects of Chandrayaan-3, Aditya-L1, and TV D1/ CES /CM missions and submitted detailed reports to the Secretary, DOS / Chairman, ISRO for confidence building on the respective missions. Reviews for the upcoming missions are planned.

Enhanced role of Space in the Health sector

Space endeavors, including technologies and procedures developed by ISRO, have had several direct and indirect benefits for the health industry. An example in this regard is the Health-QUEST programme, wherein the combined efforts of ISRO and a few Indian healthcare associations have helped in reducing human errors in the Emergency

departments (ED) of various hospitals. ISRO's homegrown Quality Assurance mechanism has been used for devising the requirements, processes, and methods related to various activities in the ED such as optimal space, patient flow, communication, training on protocols / SOPs, etc. Upon analyzing the identified Key Performance Indicators (KPI) over the pre and post-implementation regime, the study confirmed the improvement in the situation for a few KPIs. With this, the Health-Quest study is declared as completed.

In order to further widen the application of Space learnings into healthcare, brainstorming sessions were conducted with various experts from the medical field across the country. A host of areas are identified for further exploration. Discussions have been initiated to gear up these activities.

Development of Standards for the Space Industry

Standards development is of paramount importance in the space industry. The adherence to space standards by the stakeholders ensures safety, interoperability, and efficiency in space exploration, satellite deployment, and related activities. Also, it is essential to keep the developed standards up to date with the knowledge gained from time to time. Recognizing this, ISRO has reinvigorated its efforts to develop/update ISRO Technical Standards (ITecs) for various domains under its ambit.

Also, the importance of generating and following standards by the budding entrepreneurial firms in the space industry was emphasized as part of the various awareness programs conducted in this regard. Efforts are underway to generate new standards in association with the Bureau of Indian Standards for the benefit of the whole space industry in India.

Gearing up of Quality Management System for R&D environment

As ISRO is in the transition from a Production environment to R&D environment, the existing homegrown Quality Management System (QMS) also needs to adapt and tailor its quality processes to the unique characteristics and requirements of the R&D scenario. In this regard, ISRO has initiated its efforts in developing a QMS suitable to this new environment. The QMS is expected to be built with features like flexibility and innovativeness, risk managing capabilities, in-built cross-functional collaborative systems, provision for continuous improvement, training, and improving the competence of the stakeholders, auditable and monitorable, with end-product focus and high adaptability. The new QMS is going to be developed using the participatory planning method involving all the stakeholders for easy acceptability and adaptability.

Occupational Health and Safety Overview

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

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

Occupational Health and Safety activity Highlights

The space programme continued to be free from any major incidents during this year as well. The saga of launches started with the launch campaign of the second developmental flight of Small Satellite Launch Vehicle (SSLV), SSLV-D2/EOS-07 mission, followed by PSLV-C55/TE-LEOS-2, PSLV-C56/Aditya L1, PSLV-C57/DS-SAR, missions and the GSLV-F12/NVS-01 mission and the sixth consecutive successful flight of LVM3 which placed 36 satellites of OneWeb Group Company. The historic LVM3-M4/Chandrayaan-3 mission was also accomplished without any safety-related non-conformance or anomalies. Similar to previous launches, well-established safety procedures, safety standards, and emergency preparedness plan were implemented to prevent any unforeseen incidents. Safety surveillance was available round the clock during the launch campaign activities. Activities involving the production and transportation of solid propellants, earth-storable propellants, cryogenic propellants, rocket motors & pyrotechnic materials, etc; and assembly & integration of rocket stages and satellites and high-pressure gas servicing at the launch pad were carried out under the full-time participation of safety team.

The most significant achievement from a safety perspective was the testing of the Crew Escape System and the Recovery of the Crew Module on board the new launcher called Test Vehicle TV-D1, the mission was accomplished without any safety-related incidents. Another major accomplishment was the successful and safe disposal of hazardous waste in a safe and environmentally friendly manner.

2.9 Quality Management, Occupational Health & Safety

Safety surveillance was ensured during fabrication, integration, thermovac test, vibration tests and pressure hold test of the Gaganyaan Service module, Aditya-L1, and EOS-7 satellite. Safety review of radiation sources for various spacecraft was also completed without any waivers.

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

Fire fighting Programme at ISRO Headquarters

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 diverse, in tune with ISRO's enhanced capabilities and the ongoing reforms in the Indian space sector.

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 with other nations in the peaceful uses of outer space, 08 cooperative documents with foreign entities were signed during this period. They are: (i) Implementing Arrangement (IA) between ISRO and CNES (French national space agency) on the joint visible, short wave and thermal infra-red earth observation mission (TRISHNA), (ii) IA between ISRO and CNES for implementation of short term plan of maritime domain awareness of Indian ocean with existing satellite constellations, (iii) Arrangement between ISRO and European Space Agency (ESA) concerning the operational coordination of the Biomass Satellite over Indian territory, (iv) Agreement between ISRO and CNES concerning CAESAR services conjunction analysis and evaluation services alerts and recommendations and use of expert modules of JAC Software, (v) Memorandum of Understanding between ISRO and the Mauritius Research and Innovation Council concerning cooperation on the development of a joint small satellite. (vi) Agreement between ISRO and National Research and Innovation Agency of the Republic of Indonesia (BRIN) for the transfer of title of Integrated Biak TTC stations,

2.10 International Cooperation

(viii) IA between ISRO and BRIN for on operation, maintenance and utilisation of integrated Biak TTC stations and (viii) IA between ISRO and NASA for strategic framework for human spaceflight cooperation. In addition, India became a signatory to the Artemis Accord on June 21, 2023.

The cooperation in the field of space with the USA is expanded with the signing of the Artemis Accords. As a follow-up action, both sides are developing a strategic framework for cooperation in the field of human space flight. Under the US – India initiative on Critical and Emerging Technology (iCET), potential opportunities for cooperation in quantum & optical communication, ground segment for LEO constellation, etc. are being explored. The realisation of the NISAR satellite has completed critical milestones in testing at URSC where the engineers from NASA/JPL participated in the assembly, integration, and testing activities of the satellite.

The collaboration with Russia also saw progress in the field of human space flight and in the area of development/ production of launch vehicle engines. The status of the ongoing activities and the possibility of expanding the cooperation has been reviewed regularly through meetings and visits. ISRO is engaged in specific discussions with Roscosmos in developing engines for enhanced payload capacity of futuristic launch vehicles.

India – France cooperation is progressing steadily with three new agreements signed for the joint realisation of the TRISHNA mission, short-term plan for a joint maritime awareness mission, and the space object conjunction analysis support. The discussion on establishing IRIMS is also progressing. The discussions in the joint working groups on space exploration and launch vehicles are also revived considering the renewed interest from both sides. An ISRO - CNES workshop involving industry partners from both sides was organised to discuss the cooperation in launch vehicle engine development. The CNES ground station was utilized to support the Aditya-L1 missions. Discussions are on for utilizing CNES station for future ISRO missions. ISRO officials also participated in the India–France Strategic Space Dialogue discussions held in Paris.

The interactions with Japan Space Exploration Agency (JAXA) on the reception of signals from the JAXA Venus mission in the Indian Deep Space Network Antenna is continuing and the feasibility study of the joint lunar polar exploration mission is progressing.

The joint working groups of India and Italy are working closely and virtual meetings were held in the areas of Earth Observation and Space Exploration to discuss the areas of ongoing and future possible cooperation.

The discussions with Australia in the field of space are progressing with respect to placing a temporary ISRO ground station in Cocos Keeling island. Also, discussions are initiated for Australia's support for Crew Recovery operations when the Gaganyaan module lands near sea water area along the Australian coast and on possible cooperation in the field of optical communication.

The space cooperation discussions and activities are also conducted with many other nations. A web-based Geo Information System portal named "India-Oman space portal" developed by ISRO exclusively for Oman was launched. Following the high-level visit from the Saudi Space Agency (SSA) to ISRO, the areas of space cooperation were discussed and sides are presently negotiating an MoU for formalizing the discussions. The discussions on establishing an IRIMS station at the National Space Science & Technology Center(NSSTC), United Arab Emirates University, UAE have progressed with NSSTC suggesting two possible locations for the IRIMS. Through the support of the Fiji Government, a temporary transportable telemetry ground station was placed in Fiji to support the Aditya-L1 mission.

In continuation to the launch of the India – Bhutan satellite and the establishment of a ground station in Thimphu by ISRO to receive the satellite data, a one-week long training program on using the satellite data for decision-making was conducted by ISRO at Bhutan. Discussions are also initiated in establishing the ground segment for the utilisation of South Asia satellites for use by Nepal and the launching of a small satellite built by a Nepal startup onboard ISRO launch vehicles. The ISRO – Mauritius Research and Innovation Council cooperation accomplished a major milestone with the signing of the MoU for the realisation of an India – Mauritius joint small satellite and have initiated activities to form the joint working group to oversee the project execution.

Based on the announcement by the Honorable PM at the FIPIC summit, ISRO/ DOS is working on the establishment of a Space Technology Application Center (STAC) for Pacific Island Countries. Under this, an exclusive portal with geospatial data named DWEPIC - Data Warehouse for Empowering Pacific Island Countries" is being created.

Under India's G20 Presidency, ISRO/ DOS has organised the 4th edition of the Space Economy Leaders Meeting (SELM) with a Precursor event in Shillong and a main event in Bengaluru. Ambassadors/ High Commissioners /Senior Diplomats from 16 nations participated in the Precursor event and deliberated on the efforts of their respective governments to improve the space economy. In the main event, Agency Heads and senior representatives from space agencies of 18 G20 countries, 8 invited countries, and 1 international organization (ITU) participated. Additionally, 32 space industries from abroad and 53 Indian space industries actively participated in the main event. At the

2.10 International Cooperation

sideline, Chairman ISRO/Secretary, DOS had meetings with leaders of Space Agencies of Argentina, Australia, Japan, Mexico, Mauritius, Oman, Russia, Saudi Arabia, South Africa, and the UK.

Chairman, ISRO/ Secretary, DOS had bilateral meetings, on the sidelines of IAC 2023 at Baku, Azerbaijan with space agencies leaders of AEB (Brazil); ASA (Australia); ASI (Italy); CNES (France); ISA (Israel); Kazakhstan Aerospace Committee (Kazakhstan), JAXA (Japan); NASA/ JPL (USA); SSC (Saudi Arabia); SANSA (South Africa), ROSCOSMOS (Russia) KARI (South Korea) and UNOOSA and reviewed the space cooperation activities.

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-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 3500 beneficiaries from 109 countries.

ISRO participated in the events of APRSAF-29th session, Artemis Accord signatory working group, 5th Symposium of Committee on Space Research (COSPAR), International Academy of Astronautics (IAA), 74th International Astronautics Congress (IAC), 17th meeting of International Committee on Global Navigation Satellite System (ICG), UNCOPUOS and its subcommittee sessions, BRICS RSSC and QUAD space cooperation.

Ministers from Kenya and Mauritius, a Vice-Minister from Kazakhstan, and Ambassadors of Argentina, Belgium, Costa Rica, Cuba, El-Salvador, France, Norway, Peru, and Tunisia visited ISRO and had discussions with Chairman ISRO/ Secretary DOS about their respective countries ongoing and future scope of Space Cooperation.

2.11 Space Commerce

1. Background

NewSpace India Limited (NSIL) was incorporated in March 2019, as a Central Public Sector Enterprise (CPSE) under the Department of Space. It was created with the vision to spur the growth of the Indian Industry to undertake space-related activities and to provide products and services emanating from the Indian Space Programme to global customers.

In June 2020, as a part of Space Reforms under "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 Vehicles on a Demand Driven model.

As of March 31, 2023, NSIL has completed four years of its commercial space business operations. The company has substantially grown in terms of business and revenues.

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 below:

3. Business Operations

NSIL made good strides in all its major business operations as per the enhanced mandate. Major highlights of business accomplishments from April 01-December 31, 2023 are as under:

2.11 Space Commerce

3.1. Owning and operating the satellites on Demand Driven model

- **GSAT-24 [GSAT-N1] communication satellite: 1st Demand Driven Mission of NSIL**
  - NSIL successfully undertook its 1st Demand Driven Communication Satellite Mission GSAT-24 for meeting Direct-To-Home (DTH) service needs of M/s Tata Play. Entire funding for this mission has been borne by NSIL.
  - Satellite capacity services from GSAT-24 for M/s Tata Play has commenced.

- **GSAT-20 [GSAT-N2] HTS Communication Satellite: 2nd Demand Driven Mission of NSIL**
  - GSAT-20, weighing 4700 kg is a Ka-Ka-band High Throughput Satellite with 48 Gbps capacity, for meeting the Broadband connectivity needs of the Indian mainland and neighbouring islands.
  - NSIL has signed a bulk capacity utilisation commitment agreement with the user during November 2023. Entire funding for the mission would be borne by NSIL.
  - NSIL is also in discussion with other customers for utilizing the remaining capacity.
  - NSIL is planning launching of GSAT-20 satellite during Mid 2024.

- **GSAT-N3 [GSAT-32] S-Band communication satellite: 3rd Demand Driven Mission of NSIL**
  - **GSAT-N3:** GSAT-N3 is a 4500 kg S-band communication satellite meant primarily to meet the service needs of Special Users. GSAT-N3 would be the follow-on satellite to GSAT-6, which will be near its end-of-life by the end of 2024.
  - NSIL has secured commitment from Users for utilising S-band capacity utilization.
  - Entire funding for the mission would be borne by NSIL.
  - NSIL is realising the GSAT-N3 satellite through ISRO and the launch is envisaged during the first half of 2025.

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

3.2.1. Polar Satellite Launch Vehicle (PSLV)

- As part of NSIL contract with M/s HAL [Lead Partner of M/s HAL and L&T consortia] for End-to-End manufacturing of 5 nos of PSLV - 1st fully Indian Industry manufactured PSLV would be realised and launched during 2nd half of 2024.

3.2.2. Small Satellite Launch Vehicle (SSLV)

- To cater to the launch on-demand requirement of users, NSIL has initiated action towards procurement of raw materials for realising 15 SSLVs through ISRO-identified vendors.
- NSIL plan is to realise 15 SSLVs during 18-30 months.

3.2.3. Launch Vehicle Mark-3 (LVM-3)

- NSIL is working with M/s IIFCL Projects Limited (IPL) to evolve PPP or a suitable Hybrid model for End-to-End production of LVM-3 through Indian Industry consortia involving NSIL, Industry and ISRO as technology partner.

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

- During the period, NSIL undertook 2 Dedicated PSLV Launches for a customer from Singapore viz. (i) the launch of TeLEOS-2 and other co-passenger satellites from Singapore during April 2023 under a commercial arrangement with ST Engineering and (ii) the Launching of DS-SAR and other co-passenger satellites from Singapore under commercial arrangement during July 2023.

3.4. Satellite Building

- NSIL is building a Spacecraft Bus through ISRO for an Indian Customer for launch onboard PSLV during Q1 of 2024.
- NSIL has secured a contract for building 4 Spacecraft Bus through ISRO for an Indian customer and launch onboard PSLV.
- NSIL has also secured a contract for building and launching GSAT-7B Communication Satellite for the Indian Army.
- 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) establishing of Ground Segment.

2.11 Space Commerce

3.5. Satcom Services

- NSIL has been leasing space segment capacity in various bands for different applications namely DTH, VSAT, TV, DSNG, IFMC etc. on bent pipe and HTS satellites. In addition, NSIL has been leasing capacity on foreign satellites on a back-to-back basis to meet the demands of the Indian users for DTH and VSAT applications.
- Currently NSIL owns and operates 11 Communication Satellites and about 300 transponders are leased through 150+ agreements (including foreign transponders).
- NSIL has been identified as the implementing agency by the Department of Fisheries for the "National Rollout Plan for Installation of Vessel Communication and support system in Marine fishing vessels for Monitoring, control and Surveillance (MCS)" under "Pradhan Mantri Matsya Sampada Yojana (PMMSY) Scheme".
- As part of this, NSIL has identified 3 Indian Industry partners for the Supply, Installation, Operation, and management of 100,000 indigenous MSS terminals ("Xponders") on-board the fishing vessels including the creation/development of ground infrastructure.

3.6. Mission Support

- To date, NSIL has provided Thirteen Launch Vehicle Tracking Supports and Three (3) Launch and Early Orbit Phase (LEOP) support to Indian and International Customers.
- NSIL has signed 4 contracts for providing Deep Space Mission Support and Mission Support Service Contracts.
- NSIL is in discussion for providing TTC (Telemetry, Tracking, and Command) support for two Indian Industries for their satellites through ISTRAC Ground Station.

3.7. Technology Transfer & Spin-off

- In the area of Technology Transfer, the most significant achievement for NSIL has been the transfer of IMS-1 satellite bus technology to two Indian industry partners.
- To date, NSIL has signed 43 Technology Transfer Agreements for transferring ISRO-developed Technologies to Industry.

4. Corporate Social Responsibility & Sustainable Development (CSR & SD)

- NSIL has taken up CSR&SD activities in the areas of Healthcare, Education, Sanitation, Social Justice and Empowerment, Skill Development, Sustainable Development and Disaster Management Support.
- An amount of ₹ 4,94,20,085 has been identified for CSR&SD activities for the FY 2022-23 by the CSR&SD Committee. The company has undertaken the activities in association with various NGOs/ Agencies as per its CSR&SD policy.
- An amount of ₹ 8,77,81,000 has been identified for CSR&SD activities for the FY 2023-24.

5. NSIL Financials:

- As on Date, NSIL Authorised capital is ₹ 7500 Cr and Paid-up capital is ₹ 5607.60 Cr.
- NSIL's total revenue during FY 2022-23 is ₹2940.42 Cr and the Profit Before Tax is ₹ 625.76 Cr.
- NSIL's revenue for FY 2023-24 is expected to be ₹ 3700 Cr.

2.12 IN-SPACe

Authorization, Promotion, and Enablement are three major areas of operation for IN-SPACe. Under each area, a brief update on the major activities undertaken by IN-SPACe is provided below.

I. Authorization of Space activities

a. IN-SPACe has received 402 applications till October 15, 2023 from more than 250 Non-Governmental Entities (NGEs), which includes ISRO, MSMEs, start-ups, Academia and large industries. The nature of requests includes authorization, handholding, facility support and consultancy, Technology Transfer, and facility usage. Out of these 219 proposals have been disposed of and the rest of the proposals are in various stages of processing.

b. Out of the total applications received, 52 applications are for launch authorizations. Of which 22 authorizations have been issued by IN-SPACe: 09 authorizations are for space activities carried out by NGEs and 13 are for missions carried out by ISRO. Authorization applications that require Inter-Ministerial Consultation in respect of the aspects such as security, geo-political considerations, compliance to national & international regulations on spectrum and services, foreign shareholding pattern, etc., shall be referred to a Standing Committee for Inter-Ministerial Consultation (SC-IMC), which is chaired by Chairman, IN-SPACe and has representation from various government departments and ministries.

c. As of October 31, 45 MoUs and 25 JPIPs have been signed with various NGEs to extend the necessary support for carrying out the space activities. Tasks against 18 JPIPs have been completed and closed.

d. IN-SPACe has registered 14 Indian Entities who wish to disseminate/sell the primary data pertaining to Indian territory and Ground Sampling Data (GSD) > 30 cm commercially from the Earth Observation / Remote Sensing satellites.

e. IN-SPACe has issued 10 Advisory notes/NOC to NGEs to enable submission of ITU filings to ITU-R through the WPC Wing of DoT and seeking a SCOMET license from DGFT.

f. Detailed guidelines and directives for authorization of space activities are prepared in line with the Indian Space Policy – 2023 (ISP-2023). These draft guidelines have been revised based on the two rounds of feedback from the Industry. The guidelines shall be released after the review by the Standing Committee for Inter-Ministerial Coordination (SC-IMC) followed by legal vetting and approval by the IN-SPACe Board.

g. The Guidelines for utilization of unused Indian ITU filings and coordinated orbital resources by Indian Entities and the guidelines for space debris mitigation and

registration of space objects have been drafted, which shall be issued along with the detailed guidelines and directives for authorization of space activities.

h. IN-SPACe has been actively participating in the activities associated with space spectrum management including those related to ITU-R and the upcoming World Radio Conference (WRC-23), in coordination with the WPC wing of DoT.

i. IN-SPACe has been actively participating in the activities associated with space spectrum management including those related to ITU-R and upcoming World Radio Conference (WRC-23), in coordination with WPC wing of DoT.

j. IN-SPACe has generated the list of space activities that require authorization in line with the ISP-2023. Also, the SOP for processing such authorization applications and the approving cycle has been formulated with the approval of INSPACe Board. Also, recommendations of the SC-IMC have been taken into consideration, which shall be placed before the IN-SPACe Board while seeking its approval for the authorization.

II. IN-SPACe Initiatives to enable NGE's

Some of the notable initiatives by IN-SPACe for the enablement of Space sector NGEs are:

a. IN-SPACe has been in discussion with two state governments, to enable the setting up of dedicated end-to-end manufacturing clusters for Space system products and components. A brief update on key discussions is provided below.

   - The Government of Gujarat - IN-SPACe has signed a framework MoU with the Gujarat Government on October 18, 2023, to extend technical support for the Space manufacturing park along with common infrastructure for space systems' assembly, integration, and testing at Sanand, Gujarat. IN-SPACe will also work with the State to identify potential investors for the manufacturing park.

b. IN-SPACe is facilitating the process of Transfer of Technology (ToT) from ISRO to private industries, as mandated by the Indian Space Policy.

   - IN-SPACe along with ISRO has initiated the process for transfer of Small Satellite Launch Vehicle (SSLV) technology. Expression of Interest (EoI) was floated in July 2023, on which IN-SPACe has received interest from 9 companies/consortium of companies.
   - Additionally, as of October 31, 2023, IN-SPACe has transferred 10 technologies developed at various ISRO centers to 8 NGEs.

- Summary of ToT Proposals from NGEs is given below:

Summary	Number
Applications received	47
ToT Approved	24
ToT agreement signed	10

c. To enable NGEs, to have access to high end testing software for mission planning, IN-SPACe has established a state-of-the-art Design Lab in the Bopal, Ahmedabad Campus. This lab is equipped with high-performance computing systems and high-end simulation tools required for mission planning, RF, Optical and Thermo-structural design, and analyses of space systems. Till date 12 NGEs have accessed the design lab facilities.

d. IN-SPACe released the "Catalogue of Indian Standards for Space Industry" in September 2023, compiled by IN-SPACe & Bureau of Indian Standards (BIS) based on Standards followed by ISRO and International standards. The document comprises of 15 standards published by BIS covering a spectrum of domains. Work on an additional 55 space standards is in progress that will be rolled out in collaboration with BIS by the end of 2024.

e. To interface with industry for the consultations, deliberations & adoption of International Space Standards along with best practices, IN-SPACe took the initiative to define a framework and constitute an independent Indian Industry Panel in the Bureau of Indian Standards (BIS).

f. As IN-SPACe is mandated to act as a single-window interface for the industry and is responsible for all inter-departmental coordination, a Standing Committee for Inter-Ministerial Coordination (SC-IMC) chaired by Chairman, IN-SPACe with members from IN-SPACe, DOS, DOT, MIB, MEA, DPIIT, DGFT, DST and MHA, has been constituted for reviewing and recommending the authorization applications from NGEs that require scrutiny from these Departments/Ministries. As of October 31, the committee has had five meetings and has reviewed nine authorization applications.

g. In order to ease access to foreign capital by Indian NGEs, IN-SPACe along with the Department of Space has worked on a revised FDI policy for Space Sector.

h. Price Support Policy has been implemented for NGEs for: facility support & technical support from ISRO; access to EO data of ISRO satellites & data products; Satellite Launch services, Technology Transfer, and design lab usage.

i. IN-SPACe along with ISRO, has devised a Decadal Vision and Strategy for the Indian Space Economy, which was formally released on October 10, 2023 during a press conference in Bengaluru. As per the decadal vision, the size of the Indian Space

economy is pegged at $8.4bn in 2022 and is targeted to reach $44bn by 2033, making it 7-8% of the global economy. A comprehensive roadmap for the implementation of the long-term strategy is under formulation by IN-SPACe.

j. To accelerate promising start-ups, IN-SPACe has launched a Seed Fund scheme to provide initial financial assistance to Indian early-stage space start-ups through a grant of up to INR 1 cr. Under the Seed Fund Scheme, the first announcement of opportunity in the agricultural sector using space technology was announced in April, 2023. Shortlisting of startups was done by the Expert committee and two startups have been selected for awarding the seed money.

k. IN-SPACe, in association with the Indian Institute of Technology Bombay (IIT-B), Indian Institute of Technology Madras (IIT-M), Indian Institute of Remote Sensing, and Indian Institute of Space Technology, has developed a new "Space Technology" course. The course is adopted by IIT-M from January 2023 onwards for all streams of engineering.

l. Various new Schemes to support NGEs in the Space Sector are proposed in BE 2024-25 viz. Seed Fund Scheme in Space Sector/ sub-sector, Technical Manufacturing cluster (subsidies to various states for establishing common facility), Technology Adoption Fund, Investment Incentive Scheme in Space Sector & EO constellation in PPP model, etc.

03

Resource Management

3.1 Budget at a Glance

Budget Overview

(₹ in Crore)

Sl No.	Particular	BE 2023-24	RE 2023-24	BE 2024-25
1	Establishment Expenditure	450.91	453.78	478.56
2	Space Technology	9440.66	8180.01	10087.52
3	Space Applications	1558.95	1526.29	1611.71
4	Space Sciences	138.80	139.87	133.57
5	INSAT Satellite Systems	531.00	332.73	276.00
6	Other Central Sector Expenditure	423.59	437.39	455.39
	Total	**₹12,543.91**	**₹11,070.07**	**₹13,042.75**

3.2 Human Resources

The total approved sanctioned strength of the Department as of December 01, 2023 is 20295 out of which 19248 is the sanctioned strength of ISRO & DoS. The sanctioned strength of Autonomous units & PSUs of DoS is 1047. The Scientific & technical manpower of ISRO 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 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 are inducted into the system and greater importance is attached towards the continuous development of human resources, periodically in tune with the programmatic requirements. Accordingly, the recruitment norms are fine-tuned from time to time.

The Centralised recruitments & Centre Specific recruitments are continued with revised recruitment norms in place. 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 thirteenth batch of students, who were admitted to B.Tech/dual degree during September 2019 at IIST have graduated during June 2023 and a total of 98 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.

As a new initiative, ISRO has introduced recruitment based on GATE Scores and 65 candidates were recruited during 2023.

As per the GOI guidelines on mission mode recruitment, a total of 1081 recruitments were done in different cadres during July 2022 to June 2023. Further, a plan of action for filling up the vacancies arising during 2024 is also being generated.

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 2023, a total of 490 newly joined scientists/ engineers were given induction training.

Similarly, Centralised Induction Training programmes are being given to Office Assistants and Junior Personal Assistants in Administrative areas, conducted by different Centres/ Units on a rotational basis. During 2023, a total of 400 admin personnel were given training.

Customised, exclusive management and leadership development training programmes were organised for 120 Scientists/ Engineers at executive and middle level respectively. Also, 25 women Scientists/Engineers in the middle level were provided training through an exclusive customised women leadership development programme through CII. ISRO has been participating in academic programmes conducted by the International Space University through nominations.

In addition, an average of 371 personnel was provided training through different programmes such as Structured Training Programmes of ISRO, AJNIFM training on public procurement programme and other major external executive training programmes through NIAS, i2P2M, ASCI, CII, etc.

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 de-centralised training programmes.

As part of the avenue for upskilling, ISRO has put in place a 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 the New Education Programme, ISRO has opened the scheme for acquiring masters through online programmes offered by institutes of national importance like IISc, IITs, etc. and IIST.

Capacity Building: The internship Scheme in DoS/ISRO for external participants in line with the New Education Policy is implemented in DoS to encourage and instil scientific temperament in young minds.

Information as on October 31, 2023

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	7338	273	2298	850	996	841
	(ii) Female Employees	1800	169	172	724	58	157
B.	**SCHEDULED CASTES/SCHEDULED TRIBES :**						
	(i) Number of Scheduled Caste Employees	609	62	391	232	163	210
	(ii) Number of Scheduled Tribe Employees	170	31	128	84	70	44
C.	**PERSONS WITH BENCHMARK DISABILITIES (PWBD):**						
	(i) Number of persons with Benchmark Disabilities existing						
	1. Blindness and low vision	10	1	3	11	3	8
	2. Deaf and hard of hearing	18	0	18	8	10	3
	3. Locomotor Disability including cerebral palsy, Leprosy Cured, Dwarfism, Acid Attack Victims and Muscular Dystrophy	130	16	80	36	17	7
	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	1	0	2	0	2	0
	(ii) Number of Persons with Benchmark Disabilities appointed during the year						
	1. Blindness and low vision	0	0	2	0	0	0
	2. Deaf and hard of hearing	0	0	3	0	3	1

Sl. No.	Details	Group-A		Group-B		Group-C	
	3. Locomotor Disability including cerebral palsy, Leprosy Cured, Dwarfism, Acid Attack Victims and Muscular Dystrophy	4	2	0	0	3	1
	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	6	37	63	17	172
	(ii) Number of Ex-servicemen appointed during the year	0	0	0	0	0	8
E.	**OTHER BACKWARD CLASSES:**						
	(i) Number of OBCs existing	2241	89	1225	525	549	403
	(ii) Number of OBCs appointed during the year	33	1	41	3	45	8
F.	**ECONOMICALLY WEAKER SECTION (EWSs)**						
	(i) Number of EWSs existing	3	0	13	0	18	2
	(ii) Number of EWSs appointed during the period 01.11.2022 to 31.10.2023	0	0	14	0	18	0
G.	**MINORITIES**	1008	38	1046	203	97	300
H.	**APPRENTICES TRAINING :**						
	(i) Number of Apprentices trained during the year	1680					
	(ii) Number of successful apprentices out of (i) above	1197					
	(iii) Number of apprentices appointed as regular employees during the year against apprentice quota, if any.	0					

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

TABLE - I

Sl No	Centre/Unit	Total Strength of Employees 2023-24	Strength of SC Employees 2023-24	Strength of ST Employees 2023-24
1	DOS/ISRO HQ	208	48	23
2	VSSC	4630	363	39
3	URSC	2399	266	98
4	SDSC-SHAR	2128	337	118
5	SAC	1877	147	122
6	LPSC	1282	132	22
7	NRSC	787	91	36
8	ISTRAC	413	53	15
9	MCF	290	34	15
10	ADRIN	149	12	6
11	IIRS	73	11	4
12	PRL	278	12	7
13	NARL	76	10	0
14	NESAC	54	1	7
15	IIST	95	3	0
16	HSFC	228	15	6
17	IPRC	657	130	8
18	ANTRIX	14	0	0
19	NSIL	13	0	0
20	IN-Space	25	2	1
	TOTAL	**15676**	**1667**	**527**

STATUS OF PERSONS WITH DISABILITIES IN DOS/ISRO

TABLE - II

Sl No	Centre/ Unit	Total Strength of Employees 2023-24	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	208	7	1	0	6	0	0
2	VSSC	4630	116	19	25	72	0	0
3	URSC	2399	64	8	11	42	0	3
4	SDSC-SHAR	2128	60	2	8	50	0	0
5	SAC	1877	39	2	5	32	0	0
6	LPSC	1282	35	1	8	24	0	2
7	NRSC	787	21	2	4	15	0	0
8	ISTRAC	413	14	0	0	14	0	0
9	MCF	290	2	0	0	2	0	0
10	ADRIN	149	5	0	0	5	0	0
11	IIRS	73	5	1	0	4	0	0
12	PRL	278	7	1	0	6	0	0
13	NARL	76	2	0	0	2	0	0
14	NESAC	54	1	0	0	1	0	0
15	HSFC	95	5	1	1	3	0	0
16	IIST	228	1	0	0	1	0	0
17	IPRC	657	17	0	2	15	0	0
18	Antrix	14	1	0	0	1	0	0
19	NSIL	13	1	0	0	1	0	0
20	IN-Space	25	0	0	0	0	0	0
	TOTAL	**15676**	**403**	**38**	**64**	**296**	**0**	**5**

STATUS OF REPRESENTATION OF EX-SERVICEMEN IN DOS/ISRO

TABLE - III

Sl No	Centre/Unit	Total Number of Employees in Group - C 2023-2024	Total Number of Ex-Servicemen in Group - C 2023-2024
1	DOS/ISRO HQ	22	4
2	VSSC	584	113
3	URSC	273	2
4	SDSC-SHAR	398	14
5	SAC	238	6
6	LPSC	184	30
7	NRSC	98	0
8	ISTRAC	34	2
9	MCF	53	2
10	ADRIN	18	2
11	IIRS	2	1
12	PRL	14	0
13	NARL	8	0
14	NESAC	3	0
15	HSFC	27	0
16	IIST	0	0
17	IPRC	93	21
18	Antrix	3	0
19	NSIL	0	0
20	IN-Space	0	0
	TOTAL	**2052**	**197**

WOMEN EMPLOYEES IN DOS/ISRO

TABLE - IV

Sl No	Centre/Unit	Total Number of Employees 2023-2024	Number of Women Employees 2023-2024	
			Scientific & Technical Staff	Administrative Staff
1	DOS/ISRO HQ	208	11	55
2	VSSC	4630	568	408
3	URSC	2399	555	127
4	SDSC-SHAR	2128	132	100
5	SAC	1877	235	69
6	LPSC	1282	96	97
7	NRSC	787	149	49
8	ISTRAC	413	75	32
9	MCF	290	29	13
10	ADRIN	149	30	8
11	IIRS	73	17	4
12	PRL	278	32	21
13	NARL	76	8	6
14	NESAC	54	8	4
15	HSFC	95	16	11
16	IIST	228	19	6
17	IPRC	657	45	34
18	Antrix	14	1	3
19	NSIL	13	1	3
20	IN-Space	25	3	0
	TOTAL	**15676**	**2030**	**1050**

3.3 Grant-in-Aid

Sl. No.	Program Office	Sanction No. & Date	Name of the Grantee Institute	Purpose of the Grant	Sanctioned Amount
1	SPO	No.DS_2B-13013(1)/1/2019-Sec.2, 12.07.2022	Homi Bhabha Centre for Science Education, TIFR, Mumbai	Astronomy Olympiad Programme	35,83,000.00
2	SPO	No.DS_2B-13013(2)/3/2022-Sec.2, 23.02.2023	Aryabhatta Research Institute of Observational Sciences, Nainital	Aditya-L1 Support Cell	33,21,452.00
3	SPO	1. No.DS_2B-13013(2)/5/2021-Sec.2, 26.09.2022 2. No.Ds_2B-13013(2)/4/2022-Sec.2, 24.06.2022 3.No.Ds_2B-13013(1)/5/2019-Sec.2, 23.06.2022	Presidence University, Kolkata	AstroSat AO and Ch-2 AO	16,23,100.00
4	SPO	1. No.Ds_2B-13013(2)/10/2022-Sec.2, 24.06.2022 2. No.Ds_2B-13013(2)/9/2022-Sec.2, 24.06.2022	Birla Institute of Technology Mesra, Ranchi	Ch-2 AO	11,87,920.00
5	SPO	1. No.Ds_2B-13013(2)/6/2022-Sec.2, 24.06.2022 2. No.DS_2B-13013(2)/24/2022-Sec.2, 10.01.2023	Gujarat University, Ahmedabad	Ch-2 AO	12,79,880.00
6	SPO	1. No.DS_2B-13013(2)/11/2019-Sec.2, 11.07.2022	Manipal Academy of Higher Education, MAHE	AstroSat AO	11,06,687.00
7	SPO	1. No.DS_2B-13013(2)/8/2022-Sec.2, 13.07.2022 2. No.DS_2B-13013(2)/9/2019-Sec.2, 03.10.2022 3. No.DS_2B-13013(2)/6/2019-Sec.2, 04.11.2022	Christ (Deemed to be university), Bengaluru	AstroSat AO and Ch-2 AO	16,07,089.00
8	SPO	No. DS_2B-13013(2)/1/2020-Sec.2 dated January 27, 2023	Institute of Space Science and Technology	Future Planetary Exploration Activities at IIST under Sensor Payload Development scheme	20,00,000.00
9	RESPOND	DS-2B-13012(2)/27/2022-Sec.2 09/09/2022	Indian Institute of Technology Jodhpur Jodhpur: 342 037 Rajasthan	Research Project - "To study potential protocols for satellite based secure quantum communication under ambient atmospheric conditions"	15,96,730.00

10	RESPOND	DS-2B-13012(2)/4/2022-Sec.2 15/09/2022	Amrita Vishwa Vidyapeetham Amrita Nagar, Ettimadai Coimbatore: 641 112 Tamil Nadu	Research Project - Analysis of throat film cooling for Semicryogenic Thrust chamber	13,36,000.00
11	RESPOND	DS-2B-13012(2)/28/2022-Sec.2 10/10/2022	Indian Institute of Technology (ISM) Dhanbad Dhanbad: 826 004 Jharkhand	Research Project -Abiotic synthesis of methane at the recess of martian crust and prospect of microbial life in the Noachian Mars- Constraints from experimental and meteorite studies	17,12,500.00
12	RESPOND	DS-2B-13012(2)/5/2023-Sec.2 10/02/2023	Indraprastha Institute of Information Technology Okhla Phase - III Delhi: 110 020	Research Project - RES-ISTRAC-2022-002: Multisensor data fusion and Orbit determination with nonlinear estimation for space debris RADAR	10,57,440.00
13	RESPOND	DS-2B-13012(2)/6/2023-Sec.2 17/02/2023	Indian Institute of Technology Dharwad WALMI Campus Near High Court Dharwad: 580 011 Karnataka	Research Project -RES-MCF-2022-004: DVC-S2/ S2X Satellite Modem	10,34,835.00
14	RESPOND	DS-2B-13012(2)/4/2023-Sec.2 14/02/2023	National Institute of Technology Calicut NIT Campus, Kozhikode Kerala: 673 601	Research Project -RES-IISU-2022-008: High-Fidelity Sinusoidal Synthesizer for HRG Whole Angle Tracking	19,02,920.00
15	RESPOND	DS-2B-13012(2)/3/2023-Sec.2 17/02/2023	National Engineering College, K R Nagar, Kovilpatti: 628 503 Tamil Nadu	Research Project -RES-IISU-2022-007: Denoising Algorithm for Noise reduction in MEMS Sensors	10,65,480.00
16	RESPOND	DS-2B-13012(2)/15/2023-Sec.2 27/02/2023	CSIR- National Institute for Interdisciplinary Science and Technology (CSIR-NIIST) Industrial Estate PO Pappanamcode, Thiruvananthapuram: 695 019, Kerala	Research Project -RES-IPRC-2022-003: Development of molten regolith electrolysis process for oxygen production from simulated lunar soil	22,01,460.00

17	RESPOND	DS-2B-13012(2)/17/2023-Sec.2 09/03/2023	Indian Institute of Engineering Science and Technology, College Road Shibpur: 711 103, West Bengal	Research Project -RES-SAC-2022-005: Techniques for coexistence & integration of communication satellites and terrestrial IMT systems	12,10,000.00
18	RESPOND	DS-2B-13012(2)/39/2023-Sec.2 23/03/2023	National Institute of Technology Rourkela Rourkela: 769 008 Odisha	Research Project - RES-IISU-2022-006: Design and development of Mixed Signal SoC for Sensor Application in SCL 180nm	17,72,920.00
19	RESPOND	DS-2B-13012(2)/43/2023-Sec.2 23/03/2023	Indian Institute of Technology Ropar Birla Farm, Ropar: 140 001, Punjab	Research Project -RES-ISTRAC-2022-011: Distributed Beamforming and Beampattern Design using Drone Swarm Network	13,68,990.00
20	RESPOND	DS-2B-13012(2)/24/2023-Sec.2 23/03/2023	Indian Institute of Technology Gandhinagar Palaj, Gandhinagar: 382 005 Gujarat	Research Project- RES-SAC-2022-004: Development of techniques for ground-based source localization using sparse array on board LEO satellite	15,62,180.00
21	RESPOND	DS-2B-13012(2)/26/2023-Sec.2 23/03/2023	Indian Institute of Technology Ropar Birla Farm, Ropar: 140 001 Punjab	Research Project -RES-VSSC-2022-017: Development of durable and smart catalyst layer structures for low temperature PEM fuel cells	10,77,980.00
22	RESPOND	DS-2B-13012(2)/29/2023-Sec.2 23/03/2023	Indian Institute of Information Technology Design and Manufacturing (IIITDM) Kancheepuram Melakottaiyur, Chennai: 600 127 Tamil Nadu	Research Project- RES-VSSC-2022-016: Development of Porous Media based Condensing Heat Exchange for Space Systems	19,09,940.00

3.3 Grant-in-Aid

23	RESPOND	DS-2B-13012(2)/42/2023-Sec.2 23/03/2023	Indian Institute of Technology Ropar Rupnagar, Ropar: 140 001 Punjab	Research Project - RES-VSSC-2022-010: Spinel or Garnet ferrite thin films for satellite applications	20,00,000.00
24	RESPOND	DS-2B-13012(2)/13/2023-Sec.2 23/03/2023	Vellore Institute of Technology (VIT) Tiruvalam Road, Katpadi Vellore: 632 014 Tamil Nadu	Research Project- RES-MCF-2022-001: FFT based Spectrum Analyser	17,16,730.00
25	RESPOND	DS-2B-13012(2)/23/2023-Sec.2 24/03/2023	National Institute of Technology Rourkela Rourkela: 769 008 Odisha	Research Project -RES-ISTRAC-2022-008: Design of Micro cryogenic coolers for phased array receiver	21,58,960.00
26	RESPOND	DS-2B-13012(2)/40/2023-Sec.2 23/03/2023	National Institute of Technology Calicut Kozhikode: 673 601 Kerala	Research Project- RES-IISU-2022-002: Realization of plasma gun for atmospheric plasma polishing	19,38,960.00
27	RESPOND	DS-2B-13012(2)/27/2023-Sec.2 29/03/2023	Birla Institute of Technology and Science Pilani Goa Campus Zuarinagar: 403 726 Goa	Research Project - RES-SAC-2022-007: Development of Miniaturized Multi-Constellation Weak MBOC signal Real-Time GNSS Receiver	28,12,980.00
28	RESPOND	DS_2B-13012(2)/48/2019-Sec.2 November 24, 2022	Centre for Incubation, Innovation Research and Consultancy (CIIRC) Jyothy Institute of Technology Tataguni Off Kanakapura Road Bengaluru: 560 082 Karnataka	Research Project-Thermal Management of Space Electronics using Multi-turn Pulsating Heat Pipes (PHP)	12,22,560.00
29	RESPOND	DS_2B-13012(2)/31/2018-Sec.II dated 03/02/2023	Indian Centre for Space Physics, 43 Chalantika, Garia Station Road, Kolkata- 700 084, West Bengal	Research Project -Study of a few persistent and Transient Black Holes using ASTROSAT and other satellite data	11,13,600.00

30	RESPOND	DS_2B-13012(2)/43/2021 - Sec. II 36/06/2022	Indian Institute of Technology Palakkad Nila Campus, Kanjikode Palakkad: 678 623 Kerala	Research Project -Design and fabrication of inorganic electrochromic devices using layer engineering	11,13,600.00
31	RESPOND	DS_2B-13012(2)/30/2021-Sec.2 23/11/2022	National Institute of Technology Calicut NITC Campus Kozhikode: 673 601 Kerala	Research Project- Development of a model for generation of high-resolution gridded population map	10,54,500.00
32	RESPOND	DS_2B-13012(2)/8/2022-Sec.2 30/12/2022	Indian Institute of Science Education and Research (IISER) Bhopal: 462 066 Madhya Pradesh	Research Project - Modelling of Buried Channel MOSFET	11,65,860.00
33	RESPOND	DS_2B-13012(2)/26/2022-Sec.2 August 25, 2022	Indian Institute of Technology (BHU) Varanasi, Varanasi: 221 005 Uttar Pradesh	Annual Grants to Regional Academic Centre for Space at IIT (BHU), Varanasi during 2022-23	1,28,64,260.00
34	RESPOND	DS_2B-13012(2)/62/2019-Sec.2 August 25, 2022	National Institute of Technology Kurkshetra Kurukshetra: 136 119 Haryana	Annual Grants to Regional Academic Centre for Space at NIT, Kurukshetra during 2022-23	16,35,960.00
35	RESPOND	DS-2B-13012(2)/11/2021-Sec.2 23/03/2023	National Institute of Technology Patna, Ashok Rajpath, Mahendru, Patna, Bihar - 800 005	Annual Grants to Regional Academic Centre for Space at NIT Patna during 2022-23	26,48,960.00
36	RESPOND	DS-2B-13012(2)/6/2021-Sec.2 07/10/2022 & 08/02/2023	Malaviya National Institute of Technology (MNIT)Jaipur, J.L.N Marg, Jaipur Rajasthan - 302 017	Annual Grants to Regional Academic Centre for Space at MNIT Jaipur during 2022-23	1,69,97,468.00
37	RESPOND	DS_2B.13012(2)/9/2021-Sec.2 27/12/2022	Gauhati University, Guwahati - 781 014	Annual Grants to Regional Academic Centre for Space at Gauhati University during 2022-23	13,04,000.00
38	RESPOND	DS_2B-13012(2)/41/2018-Sec.2 14/11/2022 & 08/02/2023	Indian Institute of Science Bengaluru: 560 012, Karnataka	Annual Grants to the projects taken up under CeNSE at IISc, Bengaluru	2,85,55,000.00

3.3 Grant-in-Aid

39	RESPOND	DS_2B-13012(2)/55/2018-Sec.II 25/08/2022 & 23/11/2022	Indian Institute of Science Bengaluru: 560 012, Karnataka	Annual Grants to the projects taken up under Centre of Excellance on Advanced Mechanics of Materials at IISc, Bengaluru	93,08,000.00
40	RESPOND	OS 2B-13012(2)/53/2018- Sec. II 07/10/2022	Central University of Jammu, Jammu Rahya- Suchani (Bagla) Dist: Samba: 181 143 Jammu & Kashmir	Support towards fellowship of Research Fellows working in Satish Dhawan Centre for Space Sciences at Central University of Jammu, Jammu	14,66,050.00
41	RESPOND	B.19012/106/2015-Sec.2 06/12/2022 & 18/01/2023	National Institute of Advanced Studies (NIAS), Indian Institute of Science Campus, Bengaluru - 560 012	Support towards NIAS Ph.D programme	39,99,934.00
42	RESPOND	DS_2B.19012/54/2015-Sec.2 08/12/2022	Indian Institute of Technology Kanpur, Kanpur - 208 016 Uttar Pradesh	Annual Grants to Space Technology Cell at IIT Kanpur during 2022-23	40,29,046.00
43	RESPOND	No. 19012/65/2015-Sec.2 28/12/2022	Indian Institute of Technology Kharagpur, Kharagpur - 721 302, West Bengal	Annual Grants to Space Technology Cell at IIT Kharagpur during 2022-23	1,32,51,000.00
44	RESPOND	No. B. 19012/96/2016-Sec.2 25/08/2022	Indian Institute of Technology Bombay Powai, Mumbai: 400 076 Maharashtra	Annual Grants to Space Technology Cell at IIT Bombay, Mumbai during 2022-23	2,23,14,000.00
45	RESPOND	No. B. 19012/104/2016-Sec.2 25/08/2022	Indian Institute of Technology Madras Chennai: 600 036 Tamil Nadu	Annual Grants to Space Technology Cell at IIT Madras, Chennai during 2022-23	2,34,92,000.00
46	RESPOND	No. B. 19012/85/2015-Sec.2 31/10/2022	Indian Institute of Science Bengaluru: 560 012, Karnataka	Annual Grants to Space Technology Cell at IISc Bangalore during 2022-23	2,16,24,612.00
47	RESPOND	DS-2B-13012(2)/13/2020-Sec.2 25/08/2022	Indian Institute of Technology Roorkee Roorkee: 247 667 Uttarakhand	Annual Grants to Space Technology Cell at IIT Roorkee during 2022-23	1,57,65,000.00

48	RESPOND	DS-28-13012(2)/7/2021-Sec.2 03/03/2023	Indian Institute of Technology Delhi, HauzKhas, New Delhi-110 016	Annual Grants to Space Technology Cell at IIT Delhi during 2022-23	1,02,58,000.00
49	RESPOND	DS-2B-13012(2)/8/2021-Sec.2 25/08/2022	Indian Institute of Technology Guwahati Guwahati: 781 039 Assam	Release of balance grants of last financial year (2021-22) to ISRO- IIT Guwahati Space Technology Cell	36,69,210.00
50	RESPOND	DS-2B-19012/24/2014-Sec.2 24/03/2023	Savitribai Phule Pune University, Ganeshkhind, Pune - 411 007	Annual Grants to Joint Research Programme at SPPU, Pune during 2022-23	58,52,000.00
51	RESPOND	No.DS_2B-13013(2)/3/2022-Sec.2, 23.02.2023	Global Academy of Technology, Bengaluru	Integrated geospatial approach for sustainable water management study of Bengaluru	11,66,800.00
52	EDPO	No.DS_2B-13013(2)/3/2022-Sec.2, 23.02.2023	North Eastern Space Application Centre (NESAC)	Soil Resource Mapping on 1:50K for 7 districts of Manipur	10,00,000.00
	Total	**(Rupees Twenty Five Crores Forty Lakhs Seventeen Thousand Five Hundred Fifty Three Only)**			**25,40,17,553.00**

04

Others

4.1 Space in Parliament

Indian Space Programme continued to attract the attention of both the Houses of Parliament. Questions were answered in Parliament during January–December, 2023 as shown below:

Questions	Budget Session 2023		Monsoon Session 2023		Winter Session 2023		Total	
	11th Session of 17th Lok Sabha	259th Session of Rajya Sabha	12th Session of 17th Lok Sabha	260th Session of Rajya Sabha	14th Session 17th Lok Sabha	262nd Session of Rajya Sabha	LS	RS
Starred Questions	01	01	01	03	01	02	03	06
Unstarred Questions	16	11	06	11	19	17	41	39
Total	**17**	**12**	**07**	**14**	**20**	**19**	**44**	**45**

The Questions were with respect to Startups in Space Technology based Businesses, Private Startups offering satellite services in Karnataka, Establishment of Telemedicine Nodes, Institutions for Space Science, Capacity for future realization, Promoting Space related Industries, Private Sector in Space Industry, Strengthening of IN-SPACe, Funds allocated to Observatories, Gaganyaan Mission, Revenue of Global Space Industry, New Space Research Centre, Setting up ISRO Space Centre in Bihar, Sharing Global Space Market, Space Programmes and Missions, Geo – spatial portal Bhuvan, Status of Gaganyaan Programme, Future Realisation of Space Tourism, Private Sector in Space Industry, Space Debris orbiting the earth, Space Tourism, Production of Indigenously designed satellite components, Start-ups in the development of Space technology, Launching privately developed rockets from Sriharikota, Joint Consultative Machinery in ISRO, Socially useful technology developed by Department, India's share in Global Space Economy, Manufacturing of NISAR Satellite, Foreign Direct Investment in Space Activities, Setting up of Space Centre, ISRO Facility in Pollachi, Centres of ISRO, Building a new spaceport, FDI in Space Sector, New Space Policy, Encouraging the growth of start-ups, Indian Space Station, Revenue Generation by Launching of Foreign Satellites, Delay between Chandrayaan Mission – II and III, Opening Space Research and Technology to Private Players, Encouragement to Space Sector, Gaganyaan Mission, FDI in Space Sector, Space Tourism in the Country, Status of Chandrayaan – 3 Mission, Launch of Chandrayaan – 3, Spacetech Startups, Funds Allocated to IPRC, Mahendragiri, Launching of Chandrayaan – 3, North Eastern Space Applications Centre, IN-SPACe, India's future Space Mission, IITians Leaving ISRO, Chandrayaan- 3 Lander, Manufacturing of Rockets, MoU in Space, Programme for Space

Education, Completion of Chandrayaan – 3 Project, Cost of Chandrayaan Mission, Launch of Aditya-L1, Indian Space Tech Startups, Private Companies in Indian Space Sector, Launch of Satellites, Aditya-L1, Promoting Space Education and Research, Recruitment Drive in ISRO, Launch of Satellites, FDI in Space Sector, Centres of ISRO, Private Players in Space, Plan to Incentivise Private Sector, Achievements of ISRO, Space Programme and Missions in 2024, Country's Space Economy, Chandrayaan Missions, Promoting Indigenously Manufactured Equipment and Technologies in Space Missions, Space Technology Incubational Centres, Use of AI and Machine Learning in the Field of Space, Launching of foreign Satellites, Aligning ISRO's Activities with National Priorities, Opening the Space Sector to Private Players, Deaths of Space Scientists, Key objectives of Gaganyaan Mission, Foreign and Domestic Satellites, Steps to enhance International Collaboration in Space Exploration, India's Space Programme, Investment in Satellite Communication Infrastructure, Private Sector Participation in Space Industry, Commercial viability of Satellite Manufacturing and Launching.

During the year 2023, the Department-related Parliamentary Standing Committee on Science and Technology, Environment, Forests and Climate Change undertook a study visit to ISRO Headquarters on October 11, 2023 and discussed with the representatives of the Department of Space/ISRO.

4.2 Vigilance

Annexure-1

Category of employees	Types of cases	Cases pending as on 01.10.2022	Cases received during the period 01.10.2022 to 30.09.2023	Total (Col. 3+4)	Disposed during 01.10.2022 to 30.09.2023	Pending (Col. 5-6)
1	**2**	**3**	**4**	**5**	**6**	**7**
Group-A & Group-B (Gazetted) & Group-A (Non-Gazetted)	Disciplinary (Non-Vigilance)	14	7	21	1	20
	Disciplinary (Vigilance)	1	-	1	-	1
Group-B (Non-Gazetted) & Group C	Disciplinary (Non-Vigilance)	14	35	49	17	32
	Disciplinary (Vigilance)	-	-	-	-	-
	TOTAL	**29**	**42**	**71**	**18**	**53**

Annexure-2

Sl. No.	Particulars	
1.	Number of complaints of sexual harassment received during the period 01.10.2022 to 30.09.2023	**8**
2.	Number of complaints disposed of during the period 01.10.2022 to 30.09.2023	**10**
3.	Number of workshops on awareness programmes against sexual harassment conducted during the period 01.10.2022 to 30.09.2023	**12**

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 OLIC constituted in their respective towns. Modern communication tools and techniques were used for meetings/reviews.
- Meeting of the newly constituted DOS-DAE Joint Hindi Advisory Committee (JHAC) was held on March 20, 2023 at Vigyan Bhavan, New Delhi. Action Taken Report on the minutes of the meeting has been prepared on the points pertaining to the Department of Space.
- Department took part in the first phase of the 44th meeting of the Central Official Language Implementation Committee on November 15, 2022 and similarly took part in the first phase of the 45th meeting on October 16, 2023. Joint Director (OL), DOS Branch Secretariat, New Delhi participated in both the meetings under the Chairmanship of Secretary, DOL.
- Responsibilities of holding the 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, the Department and its Centres/Units purchased Hindi books for the Library in accordance with the target set up by DOL.
- During the year, the 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 2022-23 was drawn up by the Department. The inspection of concerned Centres/Units is being carried out by all Inspecting Officers.
- Training Programs in Hindi under the Hindi Teaching Scheme were continued in the Department. The percentage of employees having a working knowledge of Hindi in all Units/Centres of DOS/ISRO is more than 80%. 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.
- During every quarter of the year Hindi Workshops were conducted in all the Units/ Centers of DOS/ISRO, in which hands-on sessions were organized in order to work in Hindi.
- During the year, DOS/ISRO HQ imparted special training programs to work on computers for the employees of Antariksh Bhavan working in the Administrative area.
- Three-days Translation Training program was organized during July 05-07, 2023 by SDSC SHAR, Sriharikota for Junior and Senior Translation Officers of all the Centres/ Units of DOS/ISRO to enhance their translation skills.

4.3 Progressive use of Hindi

- Hindi Quiz competition on the topic "Indian Freedom Struggle" was conducted by the OL Section of DOS/ISRO HQ on August 10, 2023 under the auspices of 'Azadi ka Amrit Mahotsav'.
- As per the directives of DOL, during September 14-15, 2023, Hindi Day and Third All India Official Language Conference was organised at Chhatrapati Shivaji Maharaj Indoor Stadium, Pune, Maharashtra, and a large number of officers/employees from Units/Centers of DOS/ISRO participated in this conference.
- Hindi Day, Hindi Week, Hindi Fortnight, and Hindi Month were organized in all the Units/Centers of DOS/ISRO, during which competitions like; Essay Writing, Noting and Drafting, Crossword, Simple Translation, Dictation, Calligraphy, Hindi Typing, General Knowledge Quiz, Solo Singing, Antakshari, Vividha, etc., have been conducted. These competitions have been organised for Hindi-speaking and non-Hindi-speaking employees separately. In this connection, various Hindi competitions were conducted for family members/children of the employees on September 23, 2023. Awards and cash prizes were awarded to all the winners.
- The department always plays an active role in the activities of TOLIC. It conducts various Programs under the auspices of TOLIC. This year, on October 16, 2023, a 'Noting & Drafting' competition was conducted for the member offices of TOLIC (O-2), Bengaluru in Antariksh Bhavan. Also, many of the employees of DOS/ISRO HQ participated in the competitions conducted by the other member offices and won prizes.
- **'Incentive Scheme'** under which the officers/employees doing maximum work in Hindi during the Hindi month are awarded continued during the year. The incentive scheme of the Department **'SOLIS'** also continued during the year and officers/employees of DOS/ISRO HQ and its Centres/Units were awarded Cash Prizes and Certificates for doing routine work in Hindi.
- 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.
- During the year, the Incentive Scheme, **'Vikram Sarabhai Hindi Maulik Lekhan Yojana'** continued to encourage the Scientists of the Department to write books on Scientific subjects in Hindi. This year, the Department has received 07 (six) books from SAC, Ahmedabad. After the review process, further action for the publication of these books by the concerned Centre will be carried out.
- During the year 16th and 17th editions of 'Disha', the in-house magazine of DOS/ISRO HQ were published. Along with this, In-house Hindi magazines were brought out by various Centres/Units of the Department. As per the instructions of the Government of India, these magazines are being issued digitally by all the Centres/Units.

- Several banners, 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. Hindi versions of the English content to be uploaded on the website are being made available invariably.
- Second Sub-Committee of the Committee of Parliament on Official Language carried out inspection on the progressive use of Official Language at RRSC (Central), Nagpur and RRSC (West), Jodhpur on January 19, 2023 and February 27, 2023 respectively. The inspection of IIRS, Dehradun, ISTRAC, Lucknow and PRL, Ahmedabad was held on May 26, 2023, June 22, 2023 and July 10, 2023 respectively. In this connection, an inspection of DOS/ISRO HQ, Bengaluru and MCF, Hassan was held on July 14, 2023 and inspection of SDSC DHAR, Sriharikota was held on August 22, 2023. At present, as per the received information, the inspections of RRSC (East), Kolkata and ISTRAC, Port Blair have to be carried out by the Hon'ble committee.'
- In order to celebrate World Hindi Day on January 10, 2024, various competitions were organized in all the Centres/Units of the Department. On this occasion, competitions were conducted for Hindi-speaking and non-Hindi-speaking employees separately.
- In the Department the task of inclusion of Hindi in **COINS** and the web version of **COWAA** is underway at SDSC SHAR, Sriharikota.

Training on 'Kanthasth 2.0'

- Officers/employees of the Department participated in exercise-based One-day Training Program on **'Kanthasth 2.0'** during November 28-30, 2023 at New Delhi organized by the Department of OL with the cooperation of C-DAC, Pune.

OL Orientation Program

- An Official Language Orientation Program was organized by ISRO Propulsion Complex (IPRC), Mahendragiri during January 23-25, 2024 for OL Hindi staff from across the Department. Various domain experts delivered talks and imparted hands-on training during sessions on Kanthasth 2.0 & E-Office and other softwares related to OL implementation and translation; Management of Translation records with attractive Dashboard and Possible solutions on important remarks made by CPOL. Sharing of 'Innovative thoughts and programs implemented by various Centres/Units of ISRO/DOS' and 'Difficulties arising while implementing OL policy by various Centres/Units of ISRO/DOS' were also discussed in this program. Queries and doubts raised by the participants were deliberated and got them cleared.

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 organized Hindi Technical Seminars:

4.3 Progressive use of Hindi

Sl. No.	Center/Unit	Date	Topic
1.	ISRO Inertial Systems Unit, Thiruvananthapuram	June 02, 2023	**Technical Session:** Space Robotics A True Game Changer in Future Space Programme
2.	Department of Space/ISRO HQ, Bengaluru	December 21-22, 2023	**Technical Session:** Challenges, Applications and Future Prospects of Human Space Mission **OL Session:** **1.** Effective implementation of OL Hindi in Administrative and Technical fields – Challenges and Measures. **2.** Problems connected with Environment Pollution and their Measures Solutions. **3.** Indian Initiative in Carbon Neutral and its Significance. **4.** Role of Space Technology in Pollution Mitigation.
3.	Human Space Flight Centre, Bengaluru	January 30, 2024	**Technical Session:** Human Space Flight Programme: Gaganyaan And Beyond
4.	Regional Remote Sensing Centre (West), Jodhpur	February 16, 2024	**Technical Session:** The Nexus of Climate Change and Natural Disaster: Role of Space Technology for Building Resilience

- **Awards for OL Implementation**

TOLIC Level :

The following Centre/Unit of DOS was awarded for the best implementation of OL Hindi by its respective Town OLIC during the year:

Sl. No.	Centre/Unit	Region	Award	Year
1.	ANTRIX, Bengaluru	'C'	Consolation Prize	2022-23

Regional Level :

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

Sl. No.	Centers/Units	Region	Award	Year
1.	North East-Space Application Centre, Shillong	North-East Region (Region-'C')	Third	2022-23
2.	Development and Educational Communication, Ahmedabad	West Region (Region-'B')	Third	2022-23

4.4 Right to Information

Right to Information (RTI) Act 2005 is implemented in this Department as per the mandate of the 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)/INSPACe 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 the 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 organization, functions and duties**
     - Organization Chart
     - Work Allocation in Dept. of Space
     - Functions and duties
   - **ii. The powers and duties of officers and employees**
   - **iii. The procedure followed in the decision making process including channels of supervision and accountability**
   - **iv. The norms set for discharge of functions**
   - **v. The rules, regulations, instructions, manuals and records, held or under control or used by employees for discharging 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 employees for discharging functions:

1. 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

2. 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
   5. DOS Allotment of Residence Rules
   6. DOS Book of Financial Powers
   7. DOS Purchase Manual
   8. DOS Stores Procedure
   9. Transfer Policy – Transfer and posting of Officers in Administrative areas - guidelines

vi. A statement of the categories of documents that are held or under 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 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 officers and employees

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

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

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

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

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

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

4.4 Right to Information

xvii. Other Information

1. Official tours of Officers at the level of Joint Secretary (JS) & above.
   1. January 2022 to December 2022
   2. January 2023 to June 2023
2. Telephone numbers and addresses of Secretary and other Officers/Officials of Department of Space dealing with Parliament work
3. Transfer and Posting of Officers in Administrative Areas
4. Audit Report of the DOS/ISRO on proactive disclosure under RTI Act, 2005 (2022-2023)
5. Details of tender bids awarded, names of suppliers, rates and total amount
6. Information regarding CAG and PAC paras as well as action taken reports (ATR) on those paras which have been laid on the table of both houses of parliament
7. Frequently asked Questions (FAQs)

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

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

8. Annual Report

9. Human Resources

10. Citizen's Charter

11. Public Grievances

12. ISRO's Timeline from 1960s to Today

During the period December 2022 to November 2023, 3208 applications were received and information was disseminated under the provisions of the RTI Act. 309 Appeals were received by the First Appellate Authority and 24 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.6 of 2020 (Para No.5.1) Grant of additional increments	One	Nil	Nil	Nil	Nil
2	Report No.6 of 2020 (Para No.5.2) Silicon carbide mirror development facility	One	Nil	Nil	Nil	Nil
3	Report No.6 of 2020 (Para No.5.3) Creation of posts without approval of competent authority	One	Nil	Nil	Nil	Nil
4	Report No.6 of 2020 (Para No.5.4) Residency period for promotion fixed at lower than prescribed level	One	Nil	Nil	Nil	Nil
5	Report No.6 of 2020 (Para No.5.5) Management of civil works	One	Nil	Nil	Nil	Nil

4.5 Audit Observations

			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.21 of 2022 (Para No.2.1) Management of fabrication activities at Vikram Sarabhai Space Centre	Nil	Nil	Nil	One	Nil
7	Report No.21 of 2022 (Para No.2.2) Avoidable investment of ₹28.09 crore	One	Nil	Nil	Nil	Nil
8	Report No.21 of 2022 (Para No.2.3) Avoidable payment of Taxes and Duties of ₹69.02 lakhs	One	Nil	Nil	Nil	Nil
9	Report No.21 of 2022 (Para No.2.4) Non-utilisation of GSAT-6 Satellite	Nil	Nil	One	Nil	Nil
10	Report No.21 of 2022 (Para No.2.5) Irregular expenditure of ₹7.57 crore towards development of Sullurupeta	Nil	Nil	One	Nil	Nil

B. Summary of audit observations during 2022

1. **C&AG Report Union Government, Scientific Departments Report No. 21 of 2022 Para 2.1 titled "Management of fabrication activities at Vikram Sarabhai Space Centre"**

   Vikram Sarabhai Space Centre executed contracts for fabrication of structures for its various launch vehicles programmes without ensuring due diligence and strict compliance to the provisions of the DOS Purchase Manual. There were cases of single tender contracts continuing for prolonged periods of time, idling of infrastructure created, irregular expenditure in facility augmentation, deviations from codal provisions, as well as poor contract management.

2. **C&AG Report Union Government, Scientific Departments Report No. 21 of 2022 Para 2.2 titled "Avoidable investment of ₹28.09 crore"**

   VSSC invested ₹28.09 crore for the establishment of a Pure Grade Sodium Chlorate Crystals Manufacturing plant at Travancore Cochin Chemical Limited (TCC). The investment was avoidable since alternate suppliers were available in the market. Despite the investment in TCC, VSSC procured these Crystals from TCC at higher than the market rate, resulting in avoidable excess payment of ₹3.23 crore.

3. **C&AG Report Union Government, Scientific Departments Report No. 21 of 2022 Para 2.3 titled "Avoidable payment of Taxes and Duties of ₹69.02 lakhs"**

   Due to incorrect classification, VSSC incurred an avoidable payment of safeguard duty of ₹26.37 lakh in the import of launch vehicle consumables. Further, VSSC also made irregular payment of IGST amounting to ₹42.65 lakh on the import of DC converters.

4. **C&AG Report Union Government, Scientific Departments Report No. 21 of 2022 Para 2.4 titled "Avoidable investment of ₹28.09 crore"**

   Department of Space launched the GSAT-6 Satellite at a cost of ₹508 crore but was unable to utilize the satellite as envisaged due to the non-readiness of the ground segment of the satellite. This resulted in non-utilisation of the satellite for nearly half of its life.

5. **C&AG Report Union Government, Scientific Departments Report No. 21 of 2022 Para 2.5 titled "Irregular expenditure of ₹7.57 crore towards development of Sullurupeta"**

   Department of Space approved the proposal of Satish Dhawan Space Centre for taking up of work related to the development of Sullurpeta beyond its mandate which resulted in irregular expenditure of ₹7.57 crore.

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-1, 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 Guiana (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 Guiana (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 Guiana (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 Guiana (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 Guiana (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 Guiana (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 Guiana, 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
- On December 11, 2019, PSLV-C48 successfully launched RISAT-2BR1satellite and 9 customer satellites from Sriharikota

5.1 Milestones

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

2023

- On February 10, 2023, SSLV-D2 injected Earth Observation Satellite EOS-07, having experiments including mm-Wave Humidity Sounder and Spectrum Monitoring Payloads. It also placed Janus-1 of ANTARIS, USA and AzaadiSAT-2 realised by 750 girl students across India guided by Space Kidz India, Chennai
- On March 26, 2023, the LVM3 M3 vehicle launched 36 numbers of OneWeb India-2 satellites into their intended 450 km circular orbit with an inclination of 87.4 degrees. This contract was executed through NSIL
- On April 2, 2023, the Reusable Launch Vehicle Autonomous Landing Mission (RLV LEX) was conducted. The test was performed at the Aeronautical Test Range (ATR), Chitradurga, Karnataka. The autonomous landing was carried out under the exact conditions of a Space Re-entry vehicle's landing "high speed, unmanned, precise landing from the same return path" as if the vehicle arrives from space
- On April 22, 2023, PSLV-C55 vehicle successfully launched TeLEOS-2 satellite. This is a dedicated commercial mission through NSIL with TeLEOS-2 as primary satellite and Lumelite-4 as a co-passenger satellite. The satellites weigh about 741 kg and 16 kg, respectively. The mission had the PSLV Orbital Experimental Module (POEM), where the spent PS4 stage of the launch vehicle would be utilized as an orbital platform to carryout scientific experiments through non-separating payloads. The payloads belong to ISRO/Department of Space, Bellatrix, Dhruva Space, and the Indian Institute of Astrophysics
- On May 29, 2023, GSLV-F12 vehicle deployed the NVS-01 navigation satellite, weighing about 2232 kg, into a Geosynchronous Transfer Orbit. NVS-01 is the first of the second-generation satellites envisaged for the Navigation with Indian Constellation (NavIC) services. NVS series of satellites will sustain and augment the NavIC with enhanced features and incorporate L1 band signals additionally to widen the services
- On July 14, 2023, the LVM-3 M4 vehicle, in its fourth operational flight, launched Chandrayaan-3 to a precise Geo Transfer Orbit (GTO)
- On July 30, 2023, PSLV-C56 launched DS-SAR satellite, along with 6 co-passengers. Configured in its core-alone mode, C56 launched a 360 kg satellite into a Near-equatorial Orbit (NEO) at 5 degrees inclination and 535 km altitude
- On August 5, 2023, following a series of maneuvers, Chandrayaan-3 was inserted into the lunar orbit. The lander module was successfully separated from the propulsion module on August 17, 2023. The lander module was brought to a 25 km x 134 km orbit around the moon on August 20, 2023

5.1 Milestones

- On August 23, 2023, Chandrayaan-3 soft-landed on the moon
- On August 24, 2023, the rover descended on the lunar surface. For over 14 Earth days, in-situ scientific experiments were conducted on the moon, near its south pole
- On September 03, 2023, a hop test was conducted on Chandrayaan-3 lander. On October 13, 2023, the propulsion module was brought to an Earth-bound orbit, demonstrating the capability of Earth-return maneuvers
- On September 2, 2023, PSLV-C57 launched Aditya L1, the first Indian solar observatory, into precise orbit. Four maneuvers and a planned trajectory correction maneuver ensured Aditya-L1's Trans-Lagrangean Point 1 Insertion (TL1I) on October 8, 2023.
- On October 18, 2023, the Gaganyaan TV D1 Test Flight was accomplished. The Crew Escape System performed as intended. Performance of various separation systems incorporated into the Crew Escape System, the characteristics and deceleration systems demonstration at higher altitude & its recovery was demonstrated

2024

- The Aditya-L1 observatory was successfully injected into Halo orbit L1 on January 6, 2024
- PSLV-C58 successfully launched XPoSat, (X-ray Polarimeter Satellite) India's first dedicated polarimetry mission to study various dynamics of bright astronomical X-ray sources in extreme conditions on January 1, 2024, into the intended orbit. Both the XSPECT and POLIX payloads began astronomical observations during January and February respectively
- PSLV-C58 had the PSLV Orbital Experimental Module-3 (POEM-3) that successfully conducted 10 experiments through payloads identified and supplied by ISRO and IN-SPACe
- On February 17, 2024, GSLV-F14 successfully deployed INSAT-3DS, a meteorological satellite into the Geosynchronous Transfer Orbit (GTO). GSLV-F14/INSAT-3DS mission is fully funded by the Ministry of Earth Sciences (MoES). The satellite initiated Earth imaging operations with the first set of images captured on March 7, 2024

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

5.2 Acronyms

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
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

5.2 Acronyms

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
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

5.2 Acronyms

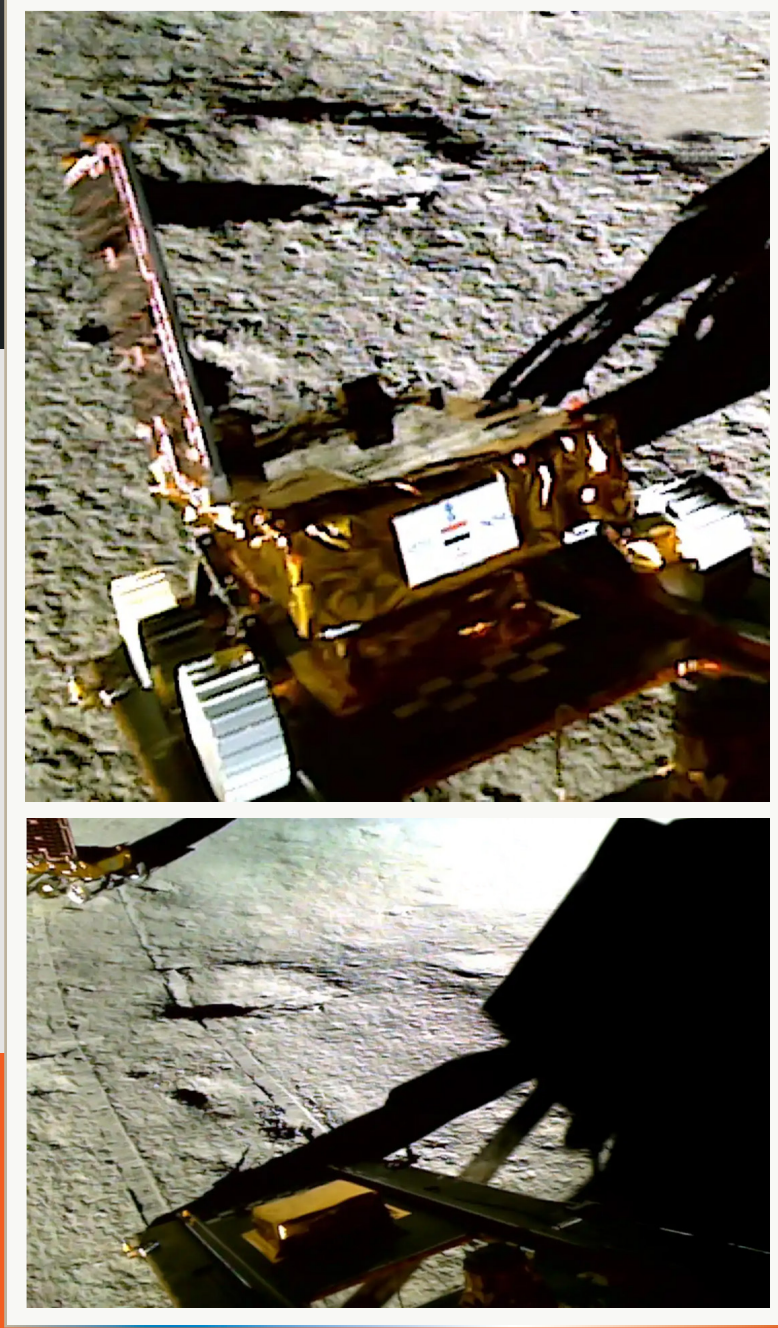
MoD	Ministry of Defence
MODIS	Moderate Resolution Imaging Spectroradiometer
MOSDAC	Meteorological and Oceanographic Satellite Data Archival Centre
MoU	Memorandum of Understanding
MRCCs	Maritime Rescue Coordination Centres
MRD	Ministry of Rural Development
MSA	Mechanical Systems Area
MSS	Mobile Satellite Services
NARL	National Atmospheric Research Laboratory
NASA	National Aeronautics and Space Administration
NavIC	Navigation with Indian Constellation
NDEM	National Database for Emergency Management
NDVI	Normalised Difference Vegetation Index
NEC	North Eastern Council
NEE	Net Ecosystem Carbon Exchange
NER	North Eastern Region
NE-SAC	North Eastern-Space Applications Centre
NGOs	Non-Government Organisations
NGPE	Non-Government Private Entity
NHP	National Hydrology Project
NICES	National Information System for Climate and Environment Studies
NISAR	NASA-ISRO Synthetic Aperture Radar
NOAA	National Oceanic and Atmospheric Administration
NPLI	National Physical Laboratory India
NRSC	National Remote Sensing Centre
NSIL	NewSpace India Limited
NSSO	National Sample Survey Office
NTU	Nanyang Technical University
NWH	North West Himalaya
OBC	On-Board computer
OCM	Ocean Colour Monitor
ORV	Orbital Re-entry Vehicle
PAT	Pad Abort Test flight

PC-NNRMS	Planning Committee on National Natural Resources Management System
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

5.2 Acronyms

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
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



Chandrayaan-3

Pragyan Rover embarks on a lunar stroll while overcoming a challenging crater in its path