



Chapter - 28 Scientific & Technological Developments

The Department of Science and Technology (DST) serves as the primary link between the science and technology sector and government verticals.

Council of Scientific & Industrial Research

- **Establishment:** Autonomous body formed in 1942.
- **Scope:** Covers diverse S&T areas such as radio physics, biotechnology, agriculture, etc.
- **Interventions:** Provides scientific solutions in environment, health, food, energy, etc.
- **Standards Custodian:** Maintains measurement standards and Traditional Knowledge Digital Library (TKDL).
- **Resources:** Manages Microbial Type Culture Collection (MTCC) and Gene Bank.
- **Intellectual Property:** Pioneers India's intellectual property movement.

Atomic Energy

- The **Department of Atomic Energy (DAE)** was established in 1954. DAE's objectives include:
 - Increasing the share of nuclear power through indigenous and proven technologies, including fast breeder reactors and thorium reactors.
 - Operating research reactors for radioisotope production and radiation technology applications in medicine, agriculture, and industry.
 - Developing advanced technologies like accelerators and lasers, fostering technology transfer to industry.
 - Supporting basic research in nuclear energy and related sciences, collaborating with universities and academic institutions, and engaging in international cooperation.
 - Contributing to national security.
- The **Heavy Water Board (HWB)** focuses on developing the 1st stage of nuclear reactors and meeting domestic heavy water demand. It's a major global producer of heavy water.
 - HWB also works on **Boron Enrichment** for the 2nd stage of the Nuclear Power Programme, developing indigenous technologies for enriched boron production.
 - **Sodium**, used as coolant in **Fast Breeder Reactors (FBRs)**, is another focus area for HWB. It has developed indigenous closed electrolytic cell technology for nuclear-grade sodium production, collaborating with Indian R&D organizations.

Indian Space Program

- Space activities in the country were initiated in **1962** with the setting up of the **Indian National Committee for Space Research (INCOSPAR)**.
 - **Indian Space Research Organisation (ISRO)** was established in August, **1969**. The Government of India constituted the Space Commission and established the Department of Space (DOS) in 1972 and brought ISRO under DOS in 1972.
- The 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.

Bhuvan:

- Geoportal platform by ISRO, offering visualisation of satellite data, thematic maps, query and analysis, free data downloads, disaster services, and geospatial applications.
- Aided COVID-19 response by hosting vaccination centres and providing maps for agroforestry suitability and property tax mapping.
- **Yuktdhara:** Geospatial planning portal developed for the Ministry of Panchayati Raj.

Gaganyaan - Human Spaceflight Mission:

- New vertical formed within ISRO, Human Spaceflight Centre (HSFC), for Gaganyaan Programme.
- Aims to demonstrate human spaceflight to Low Earth Orbit, laying the foundation for Indian human space exploration.

Space Applications:

- GSAT systems used for communication, tele-education, and telemedicine.
- Fleet of 17 communication satellites with various transponders operating over India.
- Remote sensing projects progressed through NNRMS, aiding in agricultural assessment, forest monitoring, and disaster management.
- Disaster Management Support Programme (DMS) provides space-based data and communication for disaster management.
- The Decision Support Centre (DMS-DSC) monitors natural disasters.
- National Database for Emergency Management (NDEM) offers disaster-related inputs.
- ISRO supports the International Charter for 'Space and Major Disasters' and Sentinel Asia.

Chandrayaan 3:

- Chandrayaan-3 has made history by becoming the first mission to soft-land on the lunar south pole, a region that has never been explored before. The mission aimed to demonstrate safe and soft lunar landing, rover mobility, and in-situ scientific experiments.
 - Chandrayaan-3's successful landing came after the setback of the Chandrayaan-2 mission's landing failure in 2019.
- India has now joined the US, Russia, and China as one of the few countries to successfully land on the Moon.
- The **LVM3 M4 launcher** was used to launch Chandrayaan-3.

Aditya L1 Mission:

- The ISRO successfully accomplished the launch of Aditya-L1, its inaugural Solar Mission.
 - The launch was conducted using the PSLV-C57 rocket. The PSLV's fourth stage was fired twice, a first in ISRO's history, to precisely insert the spacecraft into its elliptical orbit.
- Aditya-L1 is the first space based observatory class Indian solar mission to study the Sun from a substantial distance of 1.5 million kilometres.
 - Aditya-L1 is also ISRO's **second** astronomy observatory-class mission after AstroSat (2015).
 - The mission's journey is notably shorter than India's previous Mars orbiter mission, Mangalyaan.
- The spacecraft is planned to be placed in a halo orbit around the Lagrangian point 1 (L1) of the Sun-Earth system.

Earth Observation Satellite:

- ISRO's earth observation satellite EOS-04 and two small satellites (INSPIRESat-1 and INS-2TD) were successfully placed into the intended orbit by the PSLV-C52 rocket in Feb 2022.
- Earth observation satellites are the satellites equipped with remote sensing technology. Earth observation is the gathering of information about Earth's physical, chemical and biological systems.
 - Many earth observation satellites have been employed on sun-synchronous orbit.

NewSpace India Limited (NSIL):

- The commercial arm of the ISRO, NewSpace India Limited (NSIL) launched GSAT-20 (GSAT-N2), aboard SpaceX's Falcon-9.
 - GSAT-20 is a high throughput Ka-band satellite that provides high-speed broadband internet connectivity, digital video transmission, and audio transmission.
- NSIL, formed in 2019 operates under the Department of Space. It promotes high-tech space activities for Indian industries and commercialises space program products.
- NSIL's key areas:
 - Producing PSLV and SSLV rockets through industry collaboration.
 - Marketing space services like launches, transponder leasing, and remote sensing.
 - Building satellites based on user needs.
 - Technology transfer from ISRO.
 - Marketing spin-off technologies and consultancy services.
- In June 2022, NSIL launched GSAT-24 for Tata Play, marking its first demand-driven satellite mission.
 - Currently manages 11 communication satellites in orbit.

Small Satellite Launch Vehicle (SSLV-D2):

- ISRO's smallest vehicle, Small Satellite Launch Vehicle (SSLV-D2), was launched from the Satish Dhawan Space Centre, Sriharikota, Andhra Pradesh.
 - The vehicle's first development flight (SSLV D1) that took place in August 2022 failed to place the satellites in precise orbit.
 - In the second attempt, structural changes were made to the equipment bay, along with changes in the separation mechanism for stage 2, and logic changes for the on-board system.
- **About SSLV:** SSLV is a 3-stage launch vehicle equipped with three solid propulsion stages and a liquid propulsion-based Velocity Trimming Module (VTM) for precise terminal control.
 - Unlike the PSLV, which requires around 600 people and 6 months for assembly, SSLV can be assembled by a small team in a few days.
- **Significance:** SSLV provides low-cost access to space, boasts low turn-around time, allows for flexibility in accommodating multiple satellites, and requires minimal launch infrastructure.
- **Payloads:** SSLV-D2 deployed ISRO's earth observation satellite EOS-07 along with two co-passenger satellites: Janus-1 and AzaadiSat2.

India Space Policy 2023

The Indian Space Policy 2023 was approved by the Cabinet Committee on Security. The policy seeks to institutionalise private sector participation in the space sector, with ISRO focusing on research and development of advanced space technologies.

Major Provisions of Indian Space Policy 2023:

- **About:** Provides clarity in space reforms and boosts private industry participation in India's space economy.
- **Delineation of Roles:**
 - **NSIL:** Conducts strategic activities in a demand-driven mode, working alongside ISRO.
 - **IN-SPACE:** Acts as an interface between ISRO and non-governmental entities.
 - **ISRO:** Focuses on R&D, technology development, while operational missions are managed by NSIL.
- **Entry of Private Sector:** Allows private sector involvement in end-to-end space activities, including satellite and rocket building, data services, and launch vehicles.
 - Encourages private sector investment in new infrastructure, with access to ISRO facilities for a fee.
- **Impact:** Expected to boost India's global space economy share from less than 2% to 10% in the future.

Current Status of India's Space Sector:

- **About:**

- Globally recognized for cost-effective satellite manufacturing and launching foreign satellites.
- Committed to peaceful and civilian use of outer space, opposing weaponization via **Geneva Conference on Disarmament**.
- ISRO ranks 6th globally among space agencies with a high success rate.
- India boasts over 400 private space companies, ranking fifth globally.
- **Recent Developments:**
 - **Defence Space Agency (DSA):** Established recently with support from DSRO, focusing on developing space weapons.
 - **Defence Space Mission:** Launched by the Indian Prime Minister at Defence Expo 2022 in Gandhinagar.
 - **Satellite Manufacturing:** Expected to reach USD 3.2 billion by 2025, showing significant growth from USD 2.1 billion in 2020.
 - **SAMVAD Program:** ISRO initiated a Student Outreach Program named SAMVAD in Bengaluru to promote space research among young minds.

Earth Science

Earth system sciences study the interactions among the **atmosphere, hydrosphere, cryosphere, lithosphere, and biosphere**. The Ministry of Earth Sciences (MoES) provides comprehensive services related to weather, climate, ocean, coastal states, hydrology, and seismology.

Earth System Science Organization (ESSO):

- Established in 2007 to consolidate meteorological and ocean development activities.
- Comprises four major branches: ocean science and technology, atmospheric and climate science, geo-science and technology, and polar science and cryosphere.
- Aims to understand Earth's variability and improve forecasting capabilities for social, economic, and environmental benefits.

Air Quality-Early Warning System:

- **SAFAR (System of Air Quality and Weather Forecasting and Research)** provides real-time air quality information and forecasts up to 1-3 days in advance.
- Developed a high-resolution (400 metre) Early Warning System for Delhi, incorporating data from 36 monitoring stations and satellite data on stubble burning and dust storms.
- Helps predict extreme air pollution events in Delhi and issues warnings to implement necessary actions according to the Graded Response Action Plan.

Ocean Services: Technology and Observations

Indian National Centre for Ocean Information Services (INCOIS):

- Provides daily Potential Fishery Zone (PFZ) advisories to fishermen, aiding in locating areas with abundant fish.
- Offers ocean forecasts including waves, currents, and sea surface temperature to various stakeholders such as fisherfolk, shipping industry, and navy.
- Extended ocean forecast services to Sri Lanka and Seychelles, benefiting **Indian Ocean Rim Countries**.

Tsunami Warning System:

- Operated by INCOIS, Hyderabad, serving as the Regional Tsunami Service Provider (RSTP) for the Indian Ocean region recognized by UNESCO.
- Monitors tsunamigenic earthquakes and issues timely warnings to Indian Ocean countries through the Indian Tsunami Early Warning Centre (ITEWC).

Polar and Cryosphere Research (PACER):

- **National Centre for Antarctic and Ocean Research (NCAOR)**, Goa, established a research station called **Himansh** in the Himalayas, monitoring glaciers for mass balance, dynamics, and hydrology.

Seismology and Geoscience Research (SAGE):

- Operates a national seismological network with 115 observatories, providing information on significant earthquake events to state and central government agencies for relief and rescue operations.

Biotechnology

National Biotechnology Board (NBTB) established in 1982, upgraded to Department of Biotechnology (DBT) in 1986, promotes biotechnology activities. India ranks second in the number of USFDA-approved plants (after the US).

- **DBT Initiatives:** Emphasis on excellence and innovation in agriculture, healthcare, and medical technology.
- **GARBH-Ini:** Pregnancy cohort of 8000 women with bio-repository (Rakshita) containing 1 million biospecimens and 600,000 ultrasound images.
 - Recognized as an Atal Anusandhan Biotech Mission.
- **National Bio-Pharma Mission (NBM):** Industry-academia collaborative mission focusing on affordable vaccines and research ecosystem.
- **Mission Antimicrobial Resistance:** Launched to develop indigenous therapies, prioritise AMR, establish bio-repository, and develop diagnostic kits.
- **Nanobiotechnology:** DBT's program supporting over 300 projects since 2007, leading to advancements in drug delivery, therapeutics, and pesticide exposure prevention.

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