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An association for space industry

ISTRAC

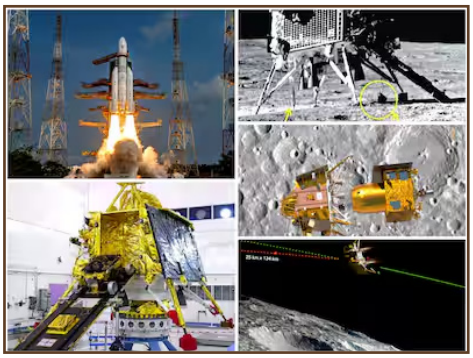
Achievements in the Last 50 Years

1. Introduction

The ISRO Telemetry, Tracking and Command Network (ISTRAC), headquartered in Bengaluru, was established in 1976 to provide round-the-clock telemetry, tracking, and command (TTC) support. Half a century later, ISTRAC remains the operational backbone of India's space program, enabling real-time communication, mission operations, control and space safety for around 120 satellites throughout their mission life along with 100 launch vehicles. Continuously evolving into a technologically advanced global network, ISTRAC supports ISRO's expanding mission operations for deep space explorations, interplanetary missions, and the upcoming Gaganyaan human spaceflight program, ensuring the success of India's satellite launches and space operations.

2. ISTRAC's Mission Operations Legacy

Its journey began with Aryabhata, India's first satellite, marking the dawn of India's independent space capabilities. Over the decades, ISTRAC has carried out mission operations for a series of landmark missions, including Chandrayaan-1, 2, and 3 for lunar exploration, the Mars Orbiter Mission (Mangalyaan) for interplanetary research, Astrosat for multi-wavelength astronomical observations, and Aditya-L1, India's ambitious solar mission. Beyond these, ISTRAC has enabled experimental and collaborative projects such as the Space Docking Experiment (SpaDEx) and the NASA-ISRO Synthetic Aperture Radar (NISAR) mission.



Through its robust ground station infrastructure of 10m/11m antennas, transportable terminals, deep space antennas of 18m and 32m and communication networks, ISTRAC has developed the state of the art Mission Operations Complex wherein real-time telemetry, health monitoring, and anomaly recovery is carried out for these missions, establishing India's credibility as a reliable and capable spacefaring nation. Each mission reflects not only the evolution of Indian space technology but also ISTRAC's growing expertise in mission-critical support, from orbital satellites to interplanetary exploration.

3. Key Technological Contributions

3.1 Navigation with Indian Constellation (NavIC)

ISTRAC has designed, developed, and operationalized the NavIC ground segment (IRIMS) across 16 locations in India, providing precise navigation, positioning, and timing services that form a critical national infrastructure. By enabling early warning dissemination, supporting fishermen and maritime safety, and facilitating search and rescue operations, NavIC has strengthened India's national security and disaster preparedness. With expansion plans underway to extend NavIC's ground segment overseas. ISTRAC is enhancing India's role in the global navigation ecosystem.

3.2 Space Situational Awareness (SSA)

ISTRAC ensures safe satellite launches and sustainable space operations through its Space Situational Awareness initiatives. Its Launch Vehicle Collision Avoidance Analysis (COLA) predicts and prevents potential launch collisions. Its Space Object Proximity Analysis (SOPA) carries out routine conjunction assessments or the safeguarding of Indian space assets from collision risks with other operational spacecraft and debris objects, ensuring mission safety. The Network for Space Object Tracking and Analysis (NETRA), India's first dedicated SSA project, continuously monitors space objects to protect satellites from collisions.

Additionally, the ISRO System for Safe and Sustainable Space Operations Management (IS4OM) provides real-time debris monitoring and the necessary guidance for controlled satellite re-entry, with notable achievements including the controlled re-entry of Megha Tropiques-1 and the de-orbiting of Cartosat-2. These efforts collectively enhance the safety, sustainability, and global credibility of India's space operations. ISTRAC team plays a major role at international level for the sustainability of outer space activities.

4. Expansion into New Frontiers

Building on decades of operational excellence, ISTRAC is expanding its ground and space-based networks to meet the growing demands of India's ambitious space program. A key initiative is the ground-based space weather observation network, which leverages radars, ionosondes, magnetometers, and GNSS receivers to monitor solar activity and its impact on Earth's upper atmosphere and magnetosphere. Complementing this, deep space radar research is being pursued to observe and track asteroids, comets, planets, moons, spacecraft, and interstellar phenomena—critical for planetary defense, astronomy, and deep space mission support. ISTRAC is also developing optical ground stations to enable quantum communication experiments, and preparing its infrastructure for climate-centric and deep ocean missions, demonstrating a forward-looking approach to space-enabled science and environmental applications. Phased Array Radars with state-of-the-art technological designs for tracking multiple space objects simultaneously are actively pursued by ISTRAC teams, which can help in cataloguing the space objects for Space Situational Awareness Purposes.

Alongside these expansions, ISTRAC is pioneering integrated solutions such as the Multi-Satellite Telemetry (MuST) system awaiting to be commissioned, designed to track, manage, and analyze telemetry data from multiple satellites simultaneously. As satellite constellations and networks grow, MuST will be essential for real-time mission control and efficient operations across Earth observation and scientific missions, enabling India to manage large-scale satellite deployments seamlessly.

5. Upgrades for Future Missions

To support upcoming missions, including the Gaganyaan human spaceflight program, ISTRAC is upgrading its infrastructure with additional and transportable terminals at all ground stations. The Indian Data Relay Satellite System (IDRSS) will ensure continuous communication with low earth orbit satellites and the Gaganyaan crew module, enabling uninterrupted command and telemetry support. Additionally, ISTRAC is developing miniaturized portable ground stations, deployable on land or sea, with CDMA modulation integrated into TTC data processors for enhanced communication reliability. These upgrades will also facilitate operations at the third launch pad at Sriharikota, ensuring readiness for a new era of Indian space exploration.

6. Technological Upgradation Roadmap to 2047

In alignment with India's 2047 space vision, ISTRAC is implementing a comprehensive modernization strategy. This includes upgrading S-band terminals to X-band and Ka-band for higher data rate operations, replacing 10-metre terminals with 11-metre multi-band systems, and developing indigenous TTC processors capable of multi-carrier operations. Further, AI-driven automation will be established across mission operations and control systems, enhancing efficiency, fault prediction, and response time. End-to-end Space Situational Awareness systems will provide real-time alerts on collision threats, ensuring satellite safety and mission continuity. Collectively, these initiatives will strengthen ISTRAC's role as a technologically advanced, globally recognized network, capable of supporting India's growing portfolio of satellites, deep space explorations, and human spaceflight missions.

7. Global Network and Future Vision

Over the past five decades, the ISRO Telemetry, Tracking and Command Network (ISTRAC) has evolved from a national support system into a globally integrated network, underpinning India's ambitious space endeavors. ISTRAC operates a comprehensive network of ground stations across India and internationally, ensuring continuous communication and control for ISRO's satellite and launch vehicle missions.

7.1 International Ground Station Network

ISTRAC's global ground station network plays a pivotal role, these stations are strategically located to offer comprehensive coverage for satellites in low Earth orbit (LEO), geostationary orbit (GEO), and deep space missions. The network includes:

- India: Bengaluru, Lucknow, Sriharikota, Thiruvananthapuram, and Port Blair
- International Locations: Port Louis (Mauritius), Biak (Indonesia), Brunei. These stations facilitate real-time communication and control, ensuring the success of various missions, including lunar explorations, interplanetary missions, and the upcoming Gaganyaan human spaceflight program.

7.2 International Collaborations

ISTRAC's global engagement extends beyond ground stations, encompassing strategic partnerships with international space agencies and organizations. Notable collaborations include NASA-ISRO Synthetic Aperture Radar (NISAR), Shared ground station support for missions such as the Gaganyaan human spaceflight program with ESA, Establishment of a ground station to support satellite communication and Earth observation initiatives in Vietnam.

7.3 Future Vision: Automation and AI Integration

Looking ahead, ISTRAC envisions a transformative approach to mission operations through the integration of automation and artificial intelligence (AI). Key initiatives include:

- **Full Automation of Mission Operations:** Implementing automated systems to streamline mission planning, execution, and monitoring, reducing human intervention and enhancing efficiency.
- **AI-Based Decision Support Systems:** Developing AI algorithms to assist in real-time decision-making, optimizing mission outcomes and resource utilization.
- **Rapid Data Relay via In-Orbit Satellites:** Establishing satellite constellations to facilitate swift data transmission between space assets and ground stations, ensuring timely communication.
- **Space Sustainability and Debris Mitigation:** Implementing strategies to monitor and manage space debris, ensuring the long-term sustainability of space operations.

By embracing these technological advancements, ISTRAC aims to maintain its position at the forefront of global space mission operations, a key component in India's expanding space ecosystem.

8. Conclusion

Over the past five decades, ISTRAC has evolved from a modest telemetry network into a world-class mission operations network. It has been responsible for the operations of every major Indian space mission, from Aryabhata to Chandrayaan-3 and continues to push the boundaries of innovation in tracking, communication, and space safety.

ISRO has been moving towards Indian Space vision 2047, building on the visionary leadership and invaluable guidance of Dr. V. Narayanan, Chairman, ISRO, whose has been instrumental in shaping ISTRAC's vision and achievements. Under the stewardship of Dr. A. K. Anil Kumar, ISTRAC is poised to play a pivotal role in Gaganyaan, interplanetary explorations, Bharatiya Antariksh Station and space sustainability initiatives with more vigour and enthusiasm.

References Based on:

Inputs received from Dr. A. K. Anil Kumar, Director, ISTRAC – and his interview on "Pivotal role in ISRO's Missions: ISTRAC (The Indian Express, 2025)"