



# Artificial Intelligence and Machine Learning in Space Sector

**For Prelims:** [Indian Space Research Organisation](#), [Artificial Intelligence](#), [Machine Learning](#), [Gaganyaan](#), NISAR, [SPADEX Experiment](#), [Bharatiya Antariksh Station](#).

**For Mains:** Role of AI and ML in Diverse Space Applications, ISRO's Future Endeavors

**Source:** [PIB](#)

## Why in News?

Recently, the Government of India highlighted the substantial strides made by the [Indian Space Research Organisation \(ISRO\)](#) in **integrating Artificial Intelligence (AI) and Machine Learning (ML)** within the realm of space exploration.

- This transformation has been a **strategic response to the rapid technological advancements** in these domains over the past few years.
- ISRO's ongoing projects, including the [Gaganyaan Program](#) have integrated AI solutions.

## How AI and ML Assist in Diverse Space Applications?

- **Space Exploration and Robotics:** AI-driven robots and rovers can navigate, make decisions, and explore distant planets or asteroids without constant human intervention.
  - ML helps in **identifying celestial objects, terrain, and hazards** in images captured by space probes or satellites.
- **Satellite Operations:** ML algorithms **analyze satellite images to monitor changes in Earth's surface**, weather patterns, and environmental changes.
  - AI helps anticipate satellite component failures by **analyzing telemetry data**, enhancing maintenance scheduling and reducing downtime.
- **Spacecraft Systems:** AI systems **monitor the health of spacecraft components**, predicting potential failures and allowing proactive maintenance.
  - **ML algorithms optimize power, fuel, and other resources** for spacecraft operations during missions.
- **Data Analysis and Pattern Recognition:** AI analyzes vast amounts of astronomical data to discover new celestial bodies, understand cosmic phenomena and identify space debris in space.
  - ML helps in processing signals from deep space, **distinguishing between noise and potential communication or scientific data**.
- **Mission Planning and Decision Making:** AI models assess mission risks, **aiding in decision-making processes** by considering various factors and scenarios.
  - ML enables spacecraft to adapt to changing environments or unexpected situations in real-time.
- **Optical Communications Optimization:** AI and ML models refine optical communication systems, adapting to changing space conditions and maximizing data transmission rates, crucial

for interplanetary missions.

- **Quantum Computing for Space Challenges:** AI has the potential to harness **quantum computing's potential to tackle complex calculations and cryptography**, enhancing security and computational capabilities for space missions requiring high-level encryption or intricate simulations.

## What AI and ML Projects are Underway in India's Space Sector?

- **AI and ML Projects:**
  - There are various projects and programmes in the domains of AI and ML being undertaken by the **Department of Space** are at different stages of feasibility studies and implementation. Major ones include:
    - **Launch vehicle and spacecrafts mission** trajectory design and autonomous operations;
    - **Launch vehicle and satellites health monitoring** and prediction from the telemetry data;
    - **Satellite Data Processing** for Resource mapping, weather prediction, disaster prediction, **geo-intelligence (object and change detection)**, Precision agriculture, Agroforestry etc.
    - **Humanoid robots and chatbots**
    - **Space Robotics** and smart manufacturing in space.
- **ISRO's Future Endeavors:**
  - **Chandrayaan-4 Mission:** Planned by ISRO to bring back samples from the Moon within four years.
  - **Bharatiya Antariksh Station (India's Space Station):** The first module, capable of conducting experiments with robots, will launch by 2028.
  - **SPADEX Experiment:** Demonstrates autonomous docking capability between two spacecraft.
    - Involves launching connected satellites that separate, travel a distance, and then reconnect.
  - **NISAR: NASA-ISRO SAR (NISAR)** is a **Low Earth Orbit (LEO) observatory** being jointly developed by NASA and ISRO.
  - **Gaganyaan:** Gaganyaan mission aims to **send humans to space and return them safely to Earth**. The mission will consist of two unmanned flights and one manned flight, using the GSLV Mk III launch vehicle and a human-rated orbital module.

### Note

- During the past 9 months of the **financial year 2023-24**, the government stated that startups in the space sector within the country have garnered **private investments exceeding 1,000 crore rupees**.

## What are Major Challenges Related to AI and ML in the Space Sector?

- **Computational Limitations:** Spacecraft have **limited computational power and memory, making it challenging to run complex AI algorithms**. ML models need to be optimized to run efficiently in these resource-constrained environments.
- **Robustness and Reliability:** Space environments are **harsh, with high levels of radiation and extreme temperatures**, which can affect the hardware and software components of AI systems. Ensuring the reliability and robustness of AI algorithms in such conditions is crucial.
- **Training Data Limitations:** Gathering training data for AI models specific to space missions can be challenging due to the **limited number of past missions or situations to learn from**.
- **Ethical and Legal Considerations:** As AI becomes more prevalent in space missions, ethical and legal concerns arise, such as the **responsibility for AI decisions, data privacy, and potential conflicts between AI-driven decisions and human judgment**.

## Way Forward

- **Edge Computing and Onboard Processing:** Focus on **onboard processing and edge computing** to minimize data transmission delays and reliance on Earth-based computational resources.
  - This **allows spacecraft to process data and make decisions autonomously**, reducing dependency on constant communication with Earth.
- **Interdisciplinary Collaboration:** Encourage collaboration between **space agencies, researchers, and industries** to combine expertise from various fields such as astronomy, computer science, materials science, and robotics.
  - This interdisciplinary approach fosters innovation and comprehensive problem-solving.
- **Ethical Frameworks and Governance:** Developing **global ethical frameworks and governance guidelines specific to AI and ML in space that** address issues like AI decision-making, accountability, data privacy, and adherence to international space laws.

## UPSC Civil Services Examination, Previous Year Question (PYQ)

### Prelims

**Q. Consider the following statements: (2016)**

**The Mangalyaan launched by ISRO**

1. is also called the Mars Orbiter Mission
2. made India the second country to have a spacecraft orbit the Mars after USA
3. made India the only country to be successful in making its spacecraft orbit the Mars in its very first attempt

**Which of the statements given above is/are correct?**

- (a) 1 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

**Ans: (c)**

### Mains

**Q. What is India's plan to have its own space station and how will it benefit our space programme? (2019)**