Sansad TV Special - Space and Beyond: The Rise of ISRO

For Prelims: National Space Day, Vikram Lander, Aditya-L1, Earth-Sun Lagrange point, L1, The Indian Space Research Organisation (ISRO), X-ray Polarimeter Satellite (XPoSat), NASA's Imaging X-ray Polarimetry Explorer (IPEX), Flight Test Vehicle Abort Mission-1 (TV-D1), Gaganyaan, Reusable Launch Vehicle, Pushpak, Small Satellite Launch Vehicle (SSLV), Agnikul Cosmos, Vikram 1 Launch Vehicle, PSLV-C58, Low Earth Orbit (LEO), Gaganyatris, Next Generation Launch Vehicle (NGLV), NASA-ISRO SAR (NISAR), Seed-Stage Funding, Brain Drain , Space Debris, ISRO's Space Situational Assessment Report 2023, Budget 2024-25, The Indian Space Policy 2023, Public-Private Partnerships (PPPs), Research and Development (R&D), Space Tourism Industry.

For Mains: The Importance of India's Space Technology Achievements and Challenges in the Space Sector.

Why in News?

Recently, National Space Day was celebrated to commemorate the successful landing of the Vikram Lander on the surface of the Moon on **23rd August 2023**.

- With the launch of Chandrayaan-3 in 2023, India became the **fourth** nation to successfully land on the Moon and the **first** to reach its **southern polar region**.
- This day highlights India's **space exploration capabilities** and aims to **inspire future generations** to pursue careers in Science, Technology, Engineering, and Mathematics (STEM), contributing to India's ongoing space endeavors.

What are the Recent Major Developments in India's Space Sector?

- **Recent Findings of Chandrayaan-3:** The terrain surrounding Chandrayaan 3's landing site is relatively **uniform**. Beneath the lunar surface, there was once a **vast sea of hot, molten rock or magma.**
  - The Moon's crust formed in layers, supporting the lunar magma ocean (LMO) hypothesis.
  - Additionally, the topsoil near the lunar south pole contains an unexpectedly **high concentration of minerals** that make up the lower layers of the lunar crust.
- **Aditya-L1 Mission:**The Aditya-L1 solar observatory, launched in September 2023, has been designed to study the Sun from the first Earth-Sun Lagrange point, L1.
  - It completed its inaugural orbit around the L1 point in July 2024 and has already made significant contributions to the study of solar storms.
- **XPoSat Launch:** In January 2024, The Indian Space Research Organisation (ISRO) launched the X-ray Polarimeter Satellite (XPoSat) to investigate radiation polarization in space.
  - This satellite is the second space-based observatory of its kind, following NASA's Imaging X-ray Polarimetry Explorer (IPEX), which was launched in 2021
- **Gaganyaan TV-D1 Test:** ISRO executed its Flight Test Vehicle Abort Mission-1 (TV-D1),

featuring a modified **L-40 Vikas engine** for the **Gaganyaan** human spaceflight mission.
    - This test validated the **Crew Escape System (CES)** capabilities, including vehicle separation, crew module safety, and deceleration before splashdown in the **Bay of Bengal**.
- **RLV-TD Experiments:** ISRO performed two landing experiments with a scaled-down version of the **Reusable Launch Vehicle, Pushpak,** in March and June 2024.
    - These tests simulated space landing conditions, with Pushpak being released from a **Chinook helicopter** to evaluate landing performance.
- **SSLV Development:** In August 2024, ISRO conducted the 3**rd and final development flight** of the **Small Satellite Launch Vehicle (SSLV)**, successfully launching the **EOS-08 and SR-0 Demosat satellites** into orbit.
    - With two consecutive successful test flights, ISRO concluded SSLV development and transitioned it to industry.
- **Mars Orbiter Mission (MOM): India's Mars Orbiter Mission (MOM), the country's first interplanetary mission, was launched aboard PSLV-C25 in 2013.**
    - ISRO became the **fourth space agency** to successfully place a spacecraft in Mars orbit.
    - The MOM aims to demonstrate advanced technology for autonomous operation during its journey and orbit insertion around Mars, while studying Martian surface features, mineralogy, and atmosphere with its five scientific payloads.
- **Private Space Missions:** In March 2024, **Agnikul Cosmos** achieved the first launch of its SoRTeD-01 vehicle, powered by a **semi-cryogenic engine** in its first stage from Indian soil.
    - **Skyroot Aerospace** is advancing towards its **Vikram 1 launch vehicle**.
    - **Dhruva Space and Bellatrix Aerospace** conducted experiments on the fourth stage of the **PSLV-C58** mission in January 2024, using it as an orbiting platform for their payloads.

What are Upcoming Space Missions by ISRO?

- **Chandrayaan-4:** India's **Chandrayaan-4 mission**, set for **2027**, will be a **sample return mission** designed to bring rock and soil samples from the Moon to Earth.
    - The spacecraft will consist of **five modules**, in contrast to the three modules of Chandrayaan-3, which included a **propulsion module**, a **lander**, and a **rover**.
    - The mission will involve **several stages**, after entering lunar orbit, two modules will detach and land on the Moon to collect samples.
    - One module will then return to the main spacecraft in lunar orbit with the samples. These samples will be transferred to a separate **Earth re-entry vehicle**, which will bring them back to Earth.

- **Gaganyaan Mission: Gaganyaan** project envisages demonstration of human spaceflight capability by launching a crew of 3 members to an orbit of **400 km** (**Low Earth Orbit (LEO)**) for 3 days.
    - ISRO is focusing on training its astronaut-candidates, known as **Gaganyatris**, for spaceflight.
    - ISRO will conduct at least **four more abort tests** before the crewed flight, with the first uncrewed Gaganyaan mission expected in late 2024. Additionally, ISRO plans to establish an Indian space station, the **Bhartiya Antriksh Station (BAS)**, **by 2035**.
- **Next-Generation Launch Vehicle:** To support the BAS and a comprehensive lunar program, ISRO is developing a new launch vehicle, the **Next Generation Launch Vehicle (NGLV)**, designed to handle heavier payloads than the current PSLV or GSLV rockets.
    - The NGLV will be a **three-stage vehicle** with a **semi-cryogenic engine**, **a liquid engine, and a cryogenic engine**.
- **NISAR: NASA-ISRO SAR (NISAR)** is a **Low Earth Orbit (LEO)** observatory being jointly developed by NASA and ISRO.
    - It will map the entire globe in **12 days** and provide spatially and temporally consistent data for understanding changes in Earth's ecosystems, ice mass, vegetation biomass, sea level rise, ground water and natural hazards including earthquakes, tsunamis, volcanoes and landslides.

What are the Major Challenges in the Indian Space Sector?

- **Limited Budget:** India's space budget is significantly smaller compared to other major space-faring nations.
    - In 2023-24, ISRO's budget was about **USD 1.7 billion**, significantly less than NASA's budget of USD 25.3 billion.
    - This limited funding constrains the scope and scale of projects that can be undertaken.
- **Technology Gap:** While India has made remarkable progress, there's still a technology gap in certain advanced areas like **human spaceflight, reusable launch vehicles, and deep space exploration.**
- **Private Sector Participation:** Despite recent policy changes to encourage private participation, the Indian space sector remains largely dominated by the government.
    - **Start-up funding** has increased in recent years but despite the increase in **early-stage and seed-stage funding**, the emerging ecosystem for private sector involvement in Indian space technology startups has yet to see any **late-stage investment**.
    - Also, this sector has yet to witness the emergence of **unicorns**.
- **Commercial Viability:** Developing a **commercially viable space industry** beyond government contracts remains a challenge.
    - The global commercial space market was valued at about **USD 630 billion** in 2023 (as per McKinsey & Company), but **India's share is around 2-3%.**
- **Underdeveloped Domestic Supply Chain:** The Indian space sector faces challenges due to an **underdeveloped domestic supply chain** for essential components and materials, leading to **heavy reliance on imports**.
    - In FY 2021-22, imports amounted to **Rs 2,114 crore**, while exports were only **Rs 174.9 crore**. This dependence on imports raises costs and risks program schedules and national security. .
- **Infrastructure and Manufacturing:** India **lacks advanced manufacturing capabilities** for certain **critical space technologies** and components.
    - For example, India still imports many high-end sensors and electronic components for its satellites.
- **International Collaboration:** While India has collaborations with several countries, it's not part of major international space projects like the **International Space Station.**
    - Geopolitical considerations sometimes limit India's access to certain technologies and partnerships.
- **Space Debris Management:** As India increases its space activities, managing **space debris** becomes crucial.
    - According to **ISRO's Space Situational Assessment Report, 2023** **82 rocket bodies** from Indian launches were placed in orbit till 2023.
    - The upper stage of **PSLV-C3** underwent an accidental break-up in 2001 and

generated **371 debris.** 52 PSLV-C3 debris were still in orbit till the end of 2023.

- **Regulatory Framework:** The regulatory environment for private space activities is still evolving.
  - **The Indian National Space Promotion and Authorization Center (IN-SPACe)** was established in 2020 to regulate private sector space activities, but the framework is still being refined.
- **Insufficient Academia-Industry-Government Collaboration:** Collaboration among academic institutions, industry, and government agencies in the space sector is currently inadequate.
  - A **Thomson Reuters** report shows that only **0.4%** of the patents have been a result of collaboration between industry and academia.
  - The absence of a structured framework for **transferring technology** from research institutions to industry impedes innovation. Although ISRO's interactions with universities are improving, they remain limited in both scope and scale.

Way Forward

- **Increase Budget Allocation:**
  - A larger budget would allow for more comprehensive research, development, and implementation of advanced space technologies.
  - In **Budget 2024-25**, the **Department of Space** received an **18% hike** over its expenses in 2023-2024.
- **Boost Private Sector Participation:**
  - Implementing **The Indian Space Policy 2023** is crucial to provide a clear regulatory framework for private companies.
  - With the goal of expanding the space economy by five times in the next 10 years, a pool of **Rs.1,000 crore**, or around **USD 120 million**, as venture capital funding for space start-ups was announced in **Budget 2024-25** .
  - Encouraging **public-private partnerships (PPPs)** for space projects can leverage the strengths of both sectors, fostering innovation and efficiency.
  - **Focus on Technology Development:**
  - Significant investment in **Research and Development (R&D)** for critical technologies is essential. This includes developing **reusable launch vehicles** to reduce launch costs, advancing propulsion systems for more efficient space travel, and creating space-grade electronics to enhance satellite capabilities.
- **Human Resource Development:**
  - Enhancing **space education programs** in universities is vital to create a skilled workforce.
  - Creating **exchange programs** with leading global space agencies can facilitate knowledge sharing and expose Indian scientists and engineers to cutting-edge practices.
- **Enhance Manufacturing Capabilities:**
  - **Encouraging technology transfer** from global leaders through strategic partnerships can help India quickly advance its manufacturing capabilities in specialized space technologies.
- **International Collaboration:**
  - India's participation in the **Artemis Accords** facilitates access to advanced training, technological advancements, and scientific opportunities.
  - Active participation in **global space initiatives and missions** can enhance India's reputation and provide valuable learning opportunities.
- **Commercialization of Space Services:**
  - Developing and promoting commercial applications of space technology in sectors like **agriculture, disaster management, and telecommunications** can create new revenue streams.
  - Supporting the development of a **space tourism industry** could position India at the forefront of this emerging market, attracting both **domestic and international investment**.
- **Space Debris Management:**
  - Investing in technologies for space debris removal and mitigation is crucial for sustainable space operations.
  - Recently, ISRO reiterated its commitment to conduct **debris-free space missions by 2030.**

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. Discuss India’s achievements in the field of Space Science and Technology. How the application of this technology has helped India in its socio-economic development? **(2016)**