Shaping the Future of India’s Space Sector

This editorial is based on “Since Chandrayaan-3, what has India’s space programme been up to?” which was published in The Hindu on 23/08/2024. The article highlights India's remarkable advancements in space exploration over the past year, including successful missions like Chandrayaan-3, Aditya L1, and Gaganyaan, while also addressing the strategic roadmaps for future endeavors and the growing role of private players in the space sector.

For Prelims: India's Space Sector, Chandrayaan-3 lunar landing, Aditya L1 Solar Mission, Gaganyaan, XPoSat, INSAT-3DS, National Space Day, NewSpace India Limited, Indian Space Policy 2023, NISAR mission, International Space Station, Pushpak reusable launch vehicle, Missile Technology Control Regime, 2019 ASAT test.

For Mains: Current Major Developments in India’s Space Sector, Major Issues Related to the Indian Space Sector.

India's Space Sector has experienced significant growth and achievements over the past year, marking a new era of innovation and exploration. From the successful Chandrayaan-3 lunar landing to the launch of the Aditya L1 Solar Mission, ISRO has demonstrated its capabilities on the global stage. The organization has also made strides in its Gaganyaan human spaceflight program, conducted critical tests for reusable launch vehicles, and expanded its satellite portfolio with missions like XPoSat and INSAT-3DS. Furthermore, the country has laid out ambitious roadmaps for lunar exploration and human spaceflight, including plans for an Indian space station by 2035.

In recognition of these milestones, India is celebrating National Space Day on 23rd August, a testament to the nation's growing prowess in space technology. However, despite these impressive accomplishments, India needs to work even more diligently to fully realize its potential in the space sector. While ISRO has made progress in research and development, there is a pressing need to accelerate the commercialization of space technologies and foster a robust private space industry. The transfer of operational responsibilities to NewSpace India Limited (NSIL**)** and the emergence of private players like Agnikul Cosmos and Skyroot Aerospace are steps in the right direction, but more needs to be done to create a thriving ecosystem of space startups and businesses.

What are the Current Major Developments in India’s Space Sector?

- **Advancements in Space Science Missions:** Following the success of Chandrayaan-3, ISRO has been actively pursuing other scientific missions.
    - The **Aditya-L1 solar observatory,** launched in September 2023, completed its first orbit around the L1 point in July 2024 and has already contributed to solar storm studies.
    - The X-ray Polarimeter Satellite (XPoSat), launched in January 2024, is advancing India's capabilities in space-based astronomy.

- **Gaganyaan Mission Progresses**: ISRO is making significant strides in its human spaceflight program, Gaganyaan.
    - In 2023, the **agency successfully conducted the first abort test (TV-D1)** of the crew escape system.
        - Four astronaut candidates have been selected and are undergoing rigorous training.
    - The **first uncrewed Gaganyaan mission is expected in late 2024**, with the crewed mission planned for 2025.
- **Commercialization and Privatization Push:** NewSpace India Limited (NSIL) is taking a more active role in commercializing ISRO's technologies.
    - In May 2024, **NSIL took over all commercial activities related to Indian Remote Sensing satellite data** and products.
    - In March 2024, **Agnikul Cosmos** successfully launched its **SoRTeD-01 vehicle**, marking a milestone for private space ventures in India.
- **Next-Generation Launch Vehicle Development**: ISRO is actively working on its Next Generation Launch Vehicle (NGLV) to enhance payload capacity and reduce launch costs.
    - The NGLV is designed to be a **three-stage vehicle powered by semi-cryogenic, liquid, and cryogenic engines.**
    - Concurrently, ISRO is developing a **semi-cryogenic engine for the LVM-3 rocket,** with successful pre-burner ignition tests conducted in May 2024.
    - These developments are crucial for India to compete in the heavy-lift launch market and support future ambitious space missions.
    - Also, the government approved the **Indian Space Policy 2023** that states that the Indian Space Research Organisation (ISRO), as the national space agency will focus primarily on the **research and development of new space technologies** and applications and on expanding the human understanding of outer space.
- **Expanding International Collaborations:** India is strengthening its space diplomacy and international partnerships.
    - **NSIL signed an agreement with SpaceX** to launch the **GSAT-20/GSAT-N2** satellite, showcasing a pragmatic approach to utilizing international launch capabilities.
    - India's collaboration with **NASA for the** NISAR mission**,** expected to launch in early 2025, demonstrates growing technical cooperation with global space leaders.
    - Additionally, Indian astronaut candidates are set to **receive training in the U.S.**, potentially leading to an **Indian presence on the** International Space Station.

What are the Major Issues Related to the Indian Space Sector?

- **Limited Private Sector Participation**: Despite recent policy reforms, India's space sector remains heavily dominated by government entities.
    - Private companies account for a minor share in India's **USD 78 billion space economy.**
    - The lack of a comprehensive regulatory framework and **limited access to ISRO's facilities** have hindered private sector growth.
    - While startups like **Skyroot Aerospace and Agnikul Cosmos** have made progress, they face challenges in scaling up.
- **Insufficient Funding and Resource Allocation**: India's **space budget**, while growing, remains modest compared to global leaders.
    - In 2023-24, ISRO's budget was approximately **USD 1.7 billion**, less than NASA's budget **(USD 25.3 billion).**
    - This limited funding affects ISRO's ability to pursue multiple ambitious projects simultaneously.
    - For instance, the development of the **Gaganyaan human spaceflight program** has faced delays partly due to resource constraints.
    - The lack of **sustained, substantial funding** also impacts long-term projects like the development of **advanced propulsion systems and next-generation launch vehicles,** potentially limiting India's competitiveness in the global space market.
- **Brain Drain and Talent Retention**: The Indian space sector faces a significant challenge in retaining top talent.
    - Significant number of aerospace engineering graduates from top Indian institutes seek opportunities abroad or in other sectors.

    - The lack of **competitive salaries, limited research opportunities, and bureaucratic hurdles** in government organizations contribute to this brain drain.
    - While ISRO has a dedicated workforce, it **struggles to compete with global tech giants** and **international space agencies** in attracting and retaining specialized talent, particularly in emerging fields like **artificial intelligence and quantum technologies applied to space.**
- **Technological Gaps in Certain Areas:** Despite impressive achievements, India lags in some critical space technologies.
    - For example, India is yet to master reusable launch vehicle technology (despite efforts like **Pushpak reusable launch vehicle)**, while companies like SpaceX have made it commonplace.
    - In satellite technology, India is still catching up in areas like **high-throughput satellites** and advanced earth observation capabilities.
    - These gaps limit India's competitiveness in the global commercial space market, where cutting-edge technology often determines market share.
- **Limited International Collaboration and Market Access:** While ISRO has collaborative agreements with over **60 countries,** the depth and scale of these collaborations often fall short of their potential.
    - **India's share in the global space economy remains under 2%,** despite having the capability to launch satellites cost-effectively.
    - Geopolitical factors, such as India's non-membership in the Missile Technology Control Regime until 2016, have historically limited technology transfers and market access.
    - Although improving, India's ability to attract major **international space projects** and secure a larger share of the global commercial launch market remains constrained by factors like **limited global marketing and stringent regulatory environments in potential partner countries.**
- **Inadequate Space Infrastructure and Ground Facilities:** India's space infrastructure, while improving, still lags behind global standards.
    - The country has only **one major launch site at Sriharikota,** limiting launch frequencies and flexibility.
    - The lack of a dedicated deep space network hampers India's ability to conduct complex interplanetary missions.
- **Underdeveloped Domestic Supply Chain:** The Indian space sector suffers from an underdeveloped domestic supply chain for critical components and materials and heavy imports.
    - During FY 2021-22, items worth **₹2,114.00 crore** were imported whereas an amount of only **₹174.9 crore** was generated from exports
    - This dependency on imports not **only increases costs but also poses risks to program schedules** and national security.
    - The lack of a robust ecosystem of suppliers for specialized materials like **composites, high-grade alloys, and electronic components** hinders the growth of both ISRO and private space companies.
- **Regulatory Hurdles and Policy Gaps**: Despite recent reforms, India's space sector still grapples with regulatory complexities.
    - The absence of a comprehensive **Space Activities Act** creates uncertainty for private players.
    - The lack of clear policies on crucial aspects like **on-orbit servicing and space resource utilization** puts India at a disadvantage in emerging space markets.
- **Limited Focus on Space Sustainability and Debris Management:** India's approach to space sustainability and debris management has been relatively passive.
    - India aims to achieve debris free space missions by 2030 but the country has not yet implemented a comprehensive space debris mitigation strategy.
    - The 2019 ASAT test, which created hundreds of debris pieces, highlighted this gap.
    - A total of **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.**
- **Insufficient Academia-Industry-Government Collaboration**: The synergy between academic institutions, industry, and government agencies in the space sector remains suboptimal.
    - Only about **0.4% of India's patents** come from academia-industry collaborations.

    - The lack of a structured framework for technology transfer from research institutions to industry hampers innovation.
    - ISRO's engagement with universities, while improving, is still limited in scope and scale.

What Measures can be Adopted to Enhance India’s Space Sector?

- **Accelerate Private Sector Integration:** Implement a **'Space Sector Transformation Program'** to fast-track private participation.
    - Establish a **one-stop-shop for space-related licenses** and approvals, reducing bureaucratic hurdles.
    - Create **'Space Enterprise Zones'** with tax incentives and simplified regulations to attract investment.
    - Develop a **public-private partnership model** for sharing ISRO's facilities and expertise with private entities.
- **Talent Retention and Development Initiative:** Introduce a **'Space Talent Retention Scheme'** offering competitive salaries and research grants to top aerospace graduates.
    - Implement a **'Space Sabbatical Program'** allowing ISRO scientists to work in private companies or foreign space agencies for skill enhancement.
    - Create an '**Aerospace Innovators'** program to identify and nurture young talent from schools and colleges. Develop exchange programs with leading global space agencies and companies for knowledge transfer and skill development.
- **Technology Leap-frog Strategy:** Launch a '**Next-Gen Space Tech Mission'** focusing on critical areas like reusable launch vehicles, quantum communication, and AI in space.
    - Establish '**Advanced Space Technology Centers'** in partnership with global tech giants to accelerate innovation in key areas.
    - Implement a '**Space Tech Transfer Program'** to adapt defense and other high-tech innovations for space applications.
    - Create a **'Space Patent Pool'** to facilitate sharing of intellectual property among Indian space entities.
- **Expand International Collaborations Strategically:** Develop bilateral **'Space Bridges'** with key countries for joint missions, technology exchange, and market access.
    - Create a '**South Asian Space Alliance'** to leverage regional cooperation and expand India's space influence.
    - Implement a '**Space Diplomacy Initiative'** using space capabilities for international development and disaster management.
    - Actively participate in forming international space laws and policies to ensure India's interests are represented.
- **Enhance Space Infrastructure and Facilities:** Develop more spaceports on the eastern coast to increase launch capabilities and flexibility.
- Establish a network of '**Mini Space Centers'** across the country for testing, assembly, and specialized research.
- Create a state-of-the-art **Deep Space Network** with multiple ground stations for enhanced deep space mission capabilities.
- Develop a **'National Space Cloud**' for efficient data storage, processing, and distribution of space-based information.
- **Strengthen Domestic Supply Chain**: Launch a '**Space Component Indigenization Mission**' to achieve **maximum localization in critical components by 2030.**
    - Establish '**Space Technology Parks**' in key industrial clusters to foster a robust supplier ecosystem.
    - Introduce **preferential procurement policies for domestically manufactured space components** to boost local production.
- **Streamline Regulatory Framework**: Enact a comprehensive **'Indian Space Activities Act'** to provide legal clarity and support for all space activities.
    - Implement a '**Fast-Track Approval System**' for space projects, with a maximum 6-month timeline for all clearances.
    - Develop clear policies on emerging areas like **space tourism, debris removal, and on-orbit servicing.**
- **Prioritize Space Sustainability:** Implement a **'National Space Debris Management Plan'** with clear guidelines and enforcement mechanisms.

    - Establish more '**Space Situational Awareness Center**' equipped with advanced tracking and monitoring capabilities.
    - Allocate dedicated funding for **developing active debris removal technologies and missions.**
    - Introduce mandatory '**End-of-Life Management Plans**' for all Indian satellites and launch vehicles.
- **Foster Academia-Industry-Government Synergy:** Create '**Space Technology Incubation Centers' i**n universities, co-managed by ISRO and industry partners.
    - Establish a '**National Space Research Consortium**' to coordinate and fund collaborative projects across sectors.
    - Launch an annual '**India Space Innovation Challenge**' with substantial grants for breakthrough ideas.

Conclusion

India's space sector has experienced substantial growth in recent years, highlighted by the successful **Chandrayaan-3 mission and the launch of Aditya L1.** However, to fully realize its potential, India must address challenges such as fostering a robust private space industry, enhancing international collaboration, and investing in critical technologies. By overcoming these obstacles, India can position itself as a major player in the global space economy and contribute to the advancement of human knowledge and exploration.

Drishti Mains Question:

Discuss the recent achievements of India's space sector and analyze the challenges and opportunities in transitioning from state-led exploration to a robust, commercialized space industry.

UPSC Civil Services Examination, Previous Year Question (PYQ)

Q.1 What is India’s plan to have its own space station and how will it benefit our space programme? **(2019)**

Q.2 Discuss India’s achievements in the field of Space Science and Technology. How the application of this technology helped India in its socio-economic development? **(2016)**

Q.3 What is the main task of India’s third mood mission which could not be achieved in its earlier mission? List the countries that have achieved this task. Introduce the subsystems in the spacecraft launched and explain the role of the ‘Virtual Launch Control Centre’ at the Vikram Sarabhai Space Centre which contributed to the successful launch from Sriharikota. **(2023)**