SPACE TECHNOLOGY: RECENT DEVELOPMENTS IN INDIA

Sunil Bishoyi

Student, Bhavan's Vivekananda College for Science, Humanities, and Commerce,
Sanikpuri, Secunderabad, India

Vedika Gupta

Student, Bhavan's Vivekananda College for Science, Humanities, and Commerce,
Sanikpuri, Secunderabad, India

Abstract

For the past few decades, the space sector has become a major priority for countries all around the world. It helps the countries to gain global recognition, boost telecommunications, and yield a deeper understanding of agriculture, sustainable development, disaster management, and many such studies. This sector ensures international peace and security between the nations. Advancements in space technology have enabled human outreach to greater extents fulfilling their curiosity to explore above and beyond what meets their eyes. Ideal utilization of such resources supports proper decision-making in the countries.

This paper analyses the growth of the space sector in India by highlighting the past important events along with the recent developments brought to the public in the field. To make the study more defined, the Indian space sector is compared to other countries in areas where it requires proper shaping and development for betterment. It states the possible solutions that will enable India to climb the ladder to the top, effectively competing with countries like the USA's NASA, Russia's Roscosmos, and China's CNSA (China National Space Administration).

Keeping in mind the upcoming missions and programs planned by ISRO and the government, if executed successfully, India will reach new heights. The objective of the paper and survey conducted is to learn about awareness among the citizens about the space sector in India.

Keywords - Space Sector, Space Technology, Privatization, Education, Space Laws, Research and Development, Missions, Communication, ISRO.

1. Introduction: History of Space Sector in India

As Gene Cernan, an American astronaut, once said, "Curiosity is the essence of our existence". So is the relationship between people and space - of Exploration, Enigma, and Enthusiasm.

India began its journey beyond the horizons of the Earth in the early 1960s and since then there is no looking back. The year 1962 saw the first step towards the development of the space sector when the Department of Atomic Energy formed INCOSPAR (Indian National Committee for Space Research) under the leadership of Dr. Vikram Sarabhai, the 'Father of Indian Space Program', and Dr. Ramanathan. ISRO (Indian Space Research Organization) was launched on 15th August 1969 to take the Indian space sector to the next level. Dr. Sarabhai headed the first Indian satellite program and successfully launched Aryabhatta in 1975.

As decades have passed, India has gradually sprawled her hands and participated in various fields of broadcasting, meteorology, and oceanography, the survey of natural resources, monitoring the environment, predicting disasters, and communication.

2. Rise of Space Technology

The timeline of the space sector in India has undergone many developments. While there are successful missions, there are also the ones that have failed but became guidance to greater achievements.

- Known as 'The largest sociological experiment in the world', SITE (Satellite Instructional Television Experiment), was a one-year program from 1975-76 conducted by ISRO along with NASA. The project covered India's 200,000 people and 2400 villages in six states. It proved to be a turning point for the world by using space communications systems for TV broadcasting in addition to educating the masses.

- On June 7, 1979, Bhaskara-I was launched as the First Experimental Remote Sensing Satellite. It was built for earth observations helping in oceanographic, Forestry, and Hydrology studies.

- An inspiration to many, Dr. APJ Abdul Kalam also called 'The Missile Man of India' many of his notable contributions, in July 1980, as Project Director successfully injected the Rohini satellite into near-earth orbit.

- Indian National Satellite (INSAT-1 A) on April 10, 1982, was launched by a US Delta rocket and favorably inserted into geostationary, though hitting a bad patch later, making it the first indigenous communication satellite.

- Marking the date on the calendar for generations to come, Rakesh Sharma on April 2, 1984, became the first and only Indian citizen to travel in space. He was a part of the first Indo-Soviet manned space mission, being one of the three members of the Soviet-Indian crew.

- By meeting with a partial failure in the first attempt in 2001, the second flight of the Geostationary Satellite Launch Vehicle on May 8, 2003, was a success. India was now capable of placing communication satellites into geosynchronous orbit.

- On November 5, 2013, with flying colors, the Indian Space Research Organization (ISRO) launched its first spacecraft to study the Red Planet - Mars. It was named Mangalyaan which means "Mars craft" in English. ISRO became the fourth space agency in the world after the United States, the Soviet Union, and the European Space Agency (ESA) successfully enter Mars orbit and explore the planet on September 23, 2014. After years of operation after landing, ISRO has collected a lot of observations about life on Mars like Martian landscapes and their composition.

- Pulling off a masterstroke on October 21, 2008, India's first mission to the Moon, Chandrayaan-1, was launched. It carried 11 scientific instruments built in India, the USA, the UK, Germany, Sweden, and Bulgaria and operated on chemical, mineralogical, and photo-geologic mapping of the Moon. The contact with the satellite was lost in 2009 after duly completing its targeted missions.

- Chandrayaan-2 was the second and a highly complex lunar exploration mission. Effectively built by ISRO, it consisted of a Launcher, Orbiter, Vikram Lander, and Pragyan Rover, that functioned to study all areas of the moon including the exosphere. It was a victorious mission that was launched on July 22, 2019.

3. Recent Developments in Space Technology

3A. Education

There is no denying the fact that education plays an essential role in expanding any sector of society. Space travel can only climb the ladder when supported by education, especially given to the youth who form the country's future and backbone.

ISRO organized a three-day Human Space Flight Expo at Jawaharlal Nehru Planetarium in Bengaluru. Celebrating India's space achievements and her 75th Independence Day, ISRO gave a glimpse of the Gaganyan mission to its audience consisting of hundreds of Bengalureans, youngsters, and parents, on how astronauts will travel in the manned mission. The most engaging part of the program was the movie show titled 'The Indian Space Odyssey -Sounding Rockets to Gaganyaan'. It impressed the audience by using exciting visualizations to show the launch vehicle, astronaut training, and then the mission sequence of the Gaganyaan. Along with this, it broadcasted the journey of ISRO for the last six decades and its substantial growth.

Atal Tinkering Labs (ATLs) was started under Atal Innovation Mission (AIM) in 2016 to make young students have a deeper understanding of space education and technology and inculcate in them research aptitude. Inspiring students of classes VI to XII through practical methods, this mission is spread over 9,600 schools across the country, and close to 40, 000 students are enrolled at 100 ATLs that were adopted by ISRO. ISRO, in 2021, collaborated with schools to provide stable mentoring by its scientist to these young minds.

YUVIKA or 'YUva VIgyani KAryakram' which means "Young Scientist Programme" was a special program organized by ISRO for school children to encourage them to take up STEM-based subjects as a career. It was to foster their minds and aware them of the advancing trends in science and technology in and around the country.

With the advancement of space technology, many other educational enhancement programs have been introduced by ISRO and the government. Not limiting it to the National level, organizations like the Society for Space, Education, Research, and Development (SSERD) help to 'elevate, educate, and empower young people across the world so that they can pursue their dreams of space in earnest ways. Though it prepares talented individuals from all parts of the world, the main focus lies on India, Nigeria, the Philippines, and Mexico.

3B. Laws and Treaties

Earlier, there were restrictions placed on private sector companies to enter the space sector. ISRO and the government held all the powers to conduct space activities, right from planning, designing, manufacturing to launching.

Only recently has the Modi government removed the restrictions, stating, "we have removed all restrictions by bringing reforms in the space sector." He also added, "I am hopeful that like in the IT sector, our industry will also take the lead in the global space sector". Henceforth, The Space Policy 2022 was announced by the government wherein the private sector could participate in activities like technology transfer, remote sensing, and satellite communication. Imaging satellites could now be owned by private companies as well. This step is a high leap for the Indian space sector when managed with mutual coordination and interest between private and public sectors. Under this, IN-SPACe will help the private sector with its operations.

UNOOSA (United Nations Office for Outer Space Affairs) is an international space organization that forms international treaties and Outer Space treaties between nations from all across the world with an aim of peaceful exploration of space. They promote sustainable economic and social development by utilizing advanced space science and technology.

3C. Upcoming Programs

ISRO has set targets for the next 2 years on their calendar with some much-awaited missions expected to be completed and executed to take the space sector of India to new heights.

Chandrayan 3 will be India's 3rd moon mission. It is expected to be launched by the first quarter of 2023 from Satish Dhawan Space Centre in a GSLV III rocket. It aims for the same objective as Chandrayan 2, to send a rover to the lunar surface after a failed attempt in 2019. If this mission is successful, India will become the 4th nation to land on the moon and the first nation to land on a south pole that is ice-riched.

Gaganyaan will be India's first program to send humans to space. In 2018, on 15th August, the mission was announced by honorable Prime Minister Narendra Modi at Red forth. Under this, two people will be sent to space for 7 days if the unmanned trial rounds manage to succeed (the first round single-handedly rockets and the second round alongside a robot). India and its people are hoping for the success of this mission, to be added as the 4th elite nation in space technology after the USA, China, and Russia.

Aditya L-1 is the first mission to the sun. During the execution of the mission, the satellite will be placed in L1 orbit around 1.5 million km away from Earth's surface. This mission is to study the properties of the Sun including solar winds and coronal mass ejections.

4. Hindrances in the Development of Space Sector In India

4A. Lack of comprehensive legislation

There are hardly a handful of laws and policies under the Indian space law system which prove to be insufficient with the pace at which the sector is growing. Some of them include Satellite Communication Policy, 2000 (SATCOM), and Remote Sensing Data Policy, 2011 (RSDP, 2011). In 2020, some of the policies introduced were in October, the Draft Space Based Communication Policy of India – 2020 (Spacecom Policy – 2020); in November, the Draft Space-Based Remote Sensing Policy of India – 2020 (SpaceRS Policy – 2020), and the Draft Norms, Guidelines and Procedures for Implementation of Space RS Policy – 2020 (SpaceRS NGP – 2020).

For example, India was placed in an international controversy against Japan, which India couldn't resolve over the fall of debris by an Indian satellite in a Japanese village that was returning to Earth. India being a signatory to the Convention on International Liability for Damage Caused by Space Objects, 1972, had an absolute liability to suffer the payment for the harm caused by its celestial object on the surface of the Earth or to aircraft when in the air. But, due to no national space law and policy, it was complex for India to conclude the quantum of damages owed. Moreover, the legislation would also pitch in to assess and determine the responsibility in the event of space debris collision with objects suspended in outer space, the damage being unavoidable.

In comparison to other countries, India needs proper legislation, especially at present with the removal of constraints on private sectors. Nations like Belgium, France, Japan, the Netherlands, the US, etc., have already enacted national space legislation. It's time for India to do the same for better management and safety.

Moreover, with more private players coming into the picture and a simultaneous increase in the commercial use of space technology in outer space, Indian legislation at present does not have a specified or in detail nature of possessory rights in outer space. It is important to focus on this for a smooth flow of operations at both the national and international levels to avoid unnecessary conflicts.

4B. Lack of Privatization

Before The Space Policy of 2022 was introduced, the private sector faced a lot of difficulties to make its name in the space sector in India. Throwing light on a few reasons, consist of -

- Unable to find investors to begin operation in the market.
- Absence of a proper framework of rules in consideration of clarity and openness.
- The absence of space law, insurance, and indemnity clarity make the organizations reluctant to contribute in case of any unforeseen events.
- No sufficient resources or technology to manage independent projects, unlike the foreign space companies such as SpaceX.
- The high tax rate in India to launch satellites makes private companies take a step back. The skewed tax policies include 18% GST (Goods and Services Tax) for Indian companies, whereas it is 0% additional for foreign companies.

4C. Lack of Education and Awareness amongst youngsters.

(i) Focus on rote learning - Schools and colleges while teaching topics related to space tend to provide more theoretical than practical knowledge. This narrows the interest and inquisitiveness of the student leading to a lack of employable skills and technical abilities.

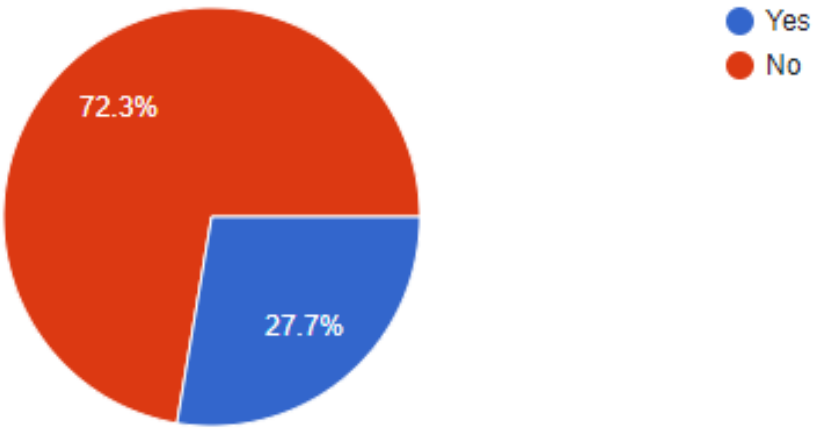
(ii) Lack of resources and infrastructures - Some schools and colleges in India make very little attempt to build labs and provide equipment to students to foster their learning of space and technology.

(iii) Lack of specialized teaching - The majority of the teachers, instructors, and trainers at the school level are under-qualified in subjects of space and technology causing students to lose their interest to take it as a career or a matter of research.

(iv) Neglecting the importance of practical knowledge - Learning institutes fail to indulge students in activities beyond the walls of the class or pages of the books. Science exhibitions, field trips, workshops, and guest lectures are sometimes considered secondary in schooling.

(v) Lack of research and development - Government fails to provide enough funds for research and development in India to researchers, students, scientists, etc., making it difficult to inflow new ideas and insights.

(vi) Lack of awareness – The survey observed that majority of the population who participated, that is 70%, were interested in the field of space. But when asked about attending some conferences, programs, or competitions, more than half of the participants, around 72.3%, denied such experience.



In a survey conducted by the authors, an incident was brought to the notice where an individual who secured 7th rank in the International Space Olympiad in school was unable to get a degree in astrophysics because of various reasons, some including a lack of colleges providing specialized courses, lack of financial scholarship, and lack of support by family due to uncertainty in the field.

4D. Lack of programs

India has participated in many space programs and missions for decades now after the formation of ISRO. But in comparison to the other nations, they resolve to be very less in number according to the data of past few years found through research.

In the year 2021- India made 2 launches (one was a failure and the other was a partial success) whereas China made 55, USA 51, and Russia 25, through NASA, Roscosmos, and CNSA, respectively.

In the year 2020 - India 2, China 39, USA 44, and Russia 17.

In the year 2019 -India 6, China 34, USA 27, and Russia 25.

In the year 2018- India 7, China 39, USA 34, and Russia 20.

It is shocking to realize that the amount of time taken to launch a single mission even after approval is lengthy. For example, Chandrayaan 1 took 9 years to launch after permission was granted and Chandrayaan 2 took 11 years for the same. Apart from this, it is unfortunate to observe that India has not published a detailed\definite space strategy till now. India has inadequate space stations to accommodate space technology. Most importantly, there aren't any manned missions performed to date. Only recently, ISRO has started a mission to send humans for 7 days.

5. Potential solutions: Research and Survey based study

India's space programs have led her to be a part of the 'space giants' which include Russia, China, and the USA. India stands at 6th position in global space technology. ISRO, playing a crucial role to lead the path for India to reach its space endeavors, has participated in 84 launchers, 115 spacecraft missions, 13 student satellites, and 342 foreign satellite programs. Though the timeline of all the historical moments is aligned with immense pride, when analyzed at a deeper level there are still areas in the Indian space sector that need to be worked upon.

5A. Promote Practical Education

Dr. APJ Abdul Kalam once said,' Education is the most powerful weapon which you can use to change the world. Educated youth can enhance a country's space sector to reach greater advancements. To make it a reality, a few steps need to be taken to shape dynamic future generations.

- Schools and colleges should take students to field trips regarding space technology at an affordable price.
- Science and space exhibitions should be conducted regularly. Parents should encourage their children to actively take part in them.
- The curriculum should be updated with recent achievements in space missions and programs.
- Exemplary institutions should be built to avoid brain drain.
- Programs, workshops, and lectures with practical presentations and visualization should be conducted in schools and colleges regarding space technology.
- Encourage youth to pursue their dreams to travel or work for space.
- Get different courses regarding space technology for U.G and P.G.

5B. Taxation and Laws

It's about time the government works on space laws and definitions to be clear and specific so that companies drawing their journey to establish themselves in the sector do not face a mistake of law or have a vague idea to carry out the venture. If the needful is not done, the quantum of damages will not be known and adjudications made on these existing precedents will be quite equivocal. Apart from that -

- The number of permissions should be decreased during the implementation of the procedure.
- Taxes for space-based products should be reduced. Ensuring easy access and feasibility to common people at affordable prices for education, research, and other purposes.
- Space laws should be definite and comprehensive; to maintain mutual understanding and harmony among nations.
- Taxation for private companies should be reduced.

5C. Promote Privatization

The private sector can help to boost ISRO to expand its horizon in space and achieve greater things for India to become the number one nation in space technology. As India is still a developing nation, it cannot invest large funds in heavy projects. Privatization can help with financial aid for the development of the space sector in a short time. Private entities will provide better and more efficient information about the projects undergoing or upcoming. Private entities encourage new ideas and give equal importance to young brains. Sharing burden among the organizations for the development of new technology at a rapid speed. It will create more employment opportunities for the people. As mentioned and promoted by the Modi government in the 'self-reliant India' mission, as well. A Few other steps that can be taken, are -

- Set up an independent tribunal to resolve disputes among private space entities.
- The passage of the Space Activities Bill should also be done to give private players greater clarity and security. Involving proper consultation and discussions with the concerned stakeholders.
- Space start-ups need to penetrate rural India and encourage youth to build careers in space applications and sciences.
- Public sectors need to establish a partnership with the private industry and entrepreneurs to enhance space business platforms that help them shorten rocketry and satellite development time to achieve first-time-right quality for successful launches.
- Public sectors could take back up from the private sector for funds, technology, research, and space exploration, including planetary exploration and manpower within the nation rather than opting from other nations.

5D. Technology, Research, and Development

Unlike before, Research and Development at present have become the basis of most of the studies and analyses conducted by various organizations and agencies. In the Indian space sector, R & D still needs to be leveled with the development outcome expected in the coming years.

- As a developing nation, the funds should be properly utilized for technology development and proper research rather than wasting it on unnecessary resources.
- Government should provide funds and opportunities to researchers, especially the young. More employment opportunities for the people should be provided and high-quality research programs should be held for interns and students. This can reduce brain drain.
- Rather than importing resources from other countries, India should be 'Atma Nirbhar' and manufacture its goods. The amount saved can later be utilized for the development of other objectives in the space sector.
- Welcome freshers and young scientists to work for ISRO and other space organizations in the nations.
- A good quality telescope is too costly for a common man. Companies should consider producing telescopes at cheaper prices, which will encourage students across the country with practical learning.
- Increasing space resources.
- Form strategies to compete with superpowers like the USA, Russia, etc., rather than depending on them for advanced technology.
- The manned space missions should be increased.

5E. Spread Awareness

In the survey conducted by the authors, it was observed that people failed to experience space-based programs at a young age leading to the gradual neglect of the field of science and space technology. According to it, 89.4% of the participants acknowledged the fact that it is necessary to educate/aware all the citizens of the country about space-related aspects. To overcome this -

- More insights and updates are to be given to the people regularly to aware them of current events taking place in and out of India.
- Government or institutions should use creative methods like visualizations to create a spark of interest in people all about space. A glance could give them a new direction.
- Government can provide a telescope at a cheaper price to schools or students who have an interest in space exploration. Private companies can do this by conducting programs.

6. Conclusion

By all counts, and based on the research and survey conducted, it is clear that India, despite developing its space sector at a considerable pace, still needs a lot of scope of development in a few areas of the field. The problems revolve around the neglecting attitude and lack of effective and potent measures taken by the government, organizations, and institutions. It ranges from inefficient and ineffective techniques adopted for education, research and development, space laws, and privatization by individuals who have the power to bring vital changes in the space sector. To begin a new phase in the space sector with optimal

utilization of resources present in the country requires a few reforms that need to be initiated by political and educational institutions in areas of inadequacy. Reforms in education, space laws, research and development, and privatization can help India gain the title of 'space giant' in the world.

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