Global Impact of India's Successful SpaDex Mission

To date, only three countries have been able to manage this rendezvous of autonomous undocking in space. The U.S. did so in 1966, with the Gemini-8 mission, which conducted the first-ever docking of two spacecraft in space in the history of mankind. Followed by Russia (erstwhile Soviet Union) in 1969 with the Soyuz and Salyut spacecraft, and China in 2011 by docking its space station Tiangong 1 with the Shenzhou-8 spacecraft. But in 1975, Russia and the US conducted the Apollo-Soyuz Test Project, where the Apollo spacecraft docked with the erstwhile Soviet Union's spacecraft, symbolizing cooperation amidst the Cold War. In 2012, China docked a crewed spacecraft with Shenzhou 9 to their space station. With this achievement, India is only the fourth space-faring nation to carry out such complex maneuvers of docking and undocking with precision (a process which allows for joining or detaching satellites while in orbit).

On January 16, 2025, at 10 am (IST), India successfully executed the Space Docking Experiment (SpaDex) in an unmanned docking by joining two SPADEX satellites, SDX01, which is the Chaser, and SDX02, the Target, each weighing approximately 220 kilograms, into a 475-kilometer orbit as per plan. This is a historical feat for India's space agency, the Indian Space Research Organisation (ISRO), which launched the SpaDeX Mission on December 30, 2024, using the 62nd Polar Satellite Launch Vehicle (PSLV) flight from the Satish Dhawan Space Centre, Sriharikota. The original docking was to be conducted on January 7, 2025. It was delayed twice to inspect further a slow drift, which caused the satellites to drift apart and made it difficult to attain a 225-meter distance between the two satellites to initiate docking with accuracy.[1]

Image 1: PSLV flight launching at Sriharikota launch pad[2]

The four main goals of this mission are:-

[1] ISRO Press Release
[2] ISRO

1. Develop technology to dock two small spacecraft.
2. Showing control over the spacecraft in the docked condition.
3. To check if the spacecraft's life can be extended (at least till 5 years)
4. Testing the power transfer between docked spacecraft.

The satellites are equipped with solar panels, a robust power management system, and lithium-ion batteries. The Attitude and Orbit Control System (AOCS) has equipped the spacecraft with star sensors, sun sensors, magnetometers, etc. These two spacecraft are androgynous, i.e., either of the spacecraft can act as the chaser during the docking process. This cost-effective mission was developed at just ₹370 crores, the major cause being ISRO using only two motors for guidance and alignment, whereas the International Docking System Standard uses 24 motors (IDSS). The process began with a movement from a 15-meter to a 3-meter hold point and ended with the docking of the two satellites. For this, the chaser satellite, in a controlled manner at a relative speed differential of 10 millimeters per second, aligns the docking parts and then performs the "handshake." Now, ISRO is managing it as one unit; there will be several maneuvers post-docking.[3]

Post-docking, the satellites will start 24 individual payloads to update ISRO with high-resolution images, orbit radiation environment, and vegetation studies. We already have two successful experiments; the first showed seed germination of cowpeas, and the second experiment unveiled their leaves in microgravity, showcasing the ability to grow crops in space.

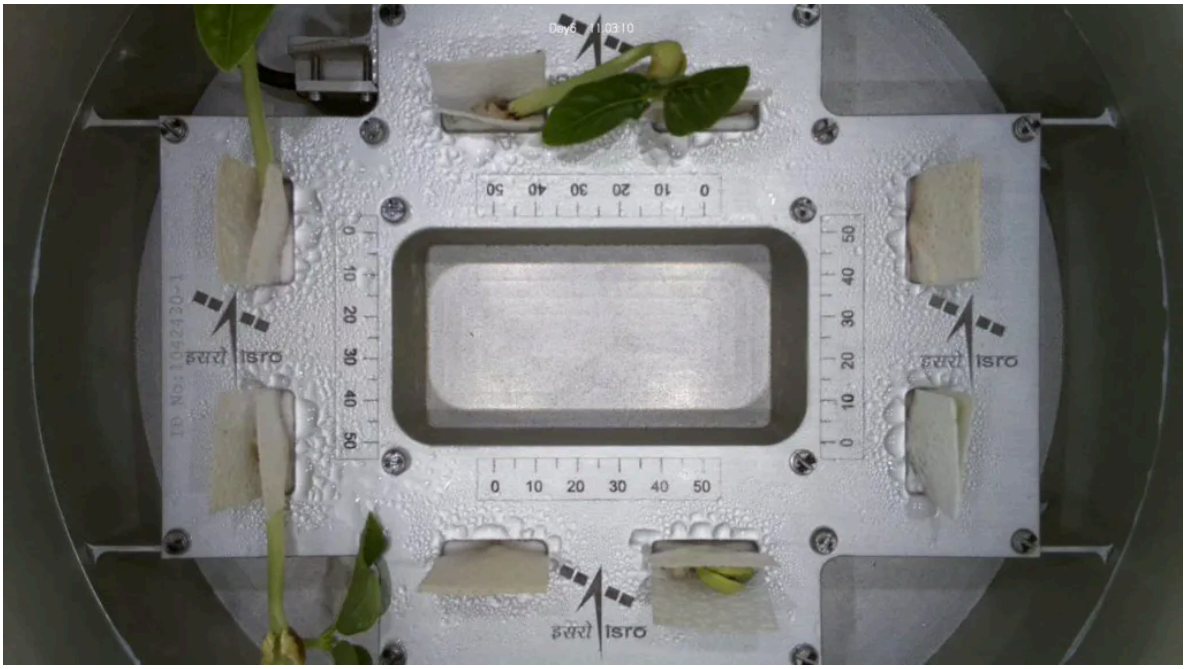

Image 2: Cowpea leaves sprouting in spacecraft's microgravity[4]

[3] ISRO Press Release
[4] ISRO

I. Enhancing Diplomatic Influence

The success of India's anonymous space docking not only solidifies a historic technological achievement but also strengthens its international diplomatic position, reinforcing India as a reliable partner in the global space sector and its future explorations. India has now shown its ability to carry out cost-effective, innovative, and efficient space exploration, making it more accessible. Now, India is looking to help nations with limited space technology to flourish in this sector and further foster stronger diplomatic relations with emerging economies. The South Asian Association initiative is India's share in exchanging technology and resources, which was proposed by Prime Minister Narendra Modi in 2014 (entirely funded by India) to help Sri Lanka, the Maldives, Bangladesh, Nepal, and Bhutan boost their telecommunication and broadcasting networks. This initiative is important for India as there is now increasing global interest in broadcasting and communication networks.

India's capabilities to lead futuristic technologies make it an important contributor to multinational projects like the Artemis Accords, joint missions with the National Aeronautics and Space Administration (NASA), European Space Agency (ESA), and Roscosmos (Russia), international space agreements, and global policy discussions and enhance India's negotiating power, benefiting its strategic interest of being a leader in affordable space technology. To open new ventures for international cooperation and peaceful cooperation, India, with its SpaDex Mission, will try to leverage its diplomatic power in the United Nations Office for Outer Space Affairs (UNOOSA), especially with the breakthrough of biological experiments- seed germination and growing of leaves in microgravity. This will help India lead international discussions on sustainable life in space- a gateway for space-based agriculture.

To boost India's space sector's market share of ₹800 crore to ₹4,400 crore by 2033 and increase its minimal 2% share in the global space sector. The Indian Space Policy, 2023, now allows private companies to take part in space activities - manufacturing satellites, rockets, and even launch vehicles. For the first time, ISRO allowed a private company, Ananth Technologies, to conduct full integration and testing of the rocket carrying out the SpaDeX Mission, under the supervision of the UR Rao Satellite Centre (URSC). This policy also allows for ISRO's facilities to be used to create infrastructure for the sector at a small fee.

This will boost Indian Space startups, foster a new wave of space entrepreneurship within the country, and improve public-private relations. Indian National Space Promotion and Authorisation Centre (in-Space) is a ₹1000 crore government-affiliated space venture capital fund for backing such startups; at least 1,170 Startups have registered so far. This policy can be a game-changer in strengthening international partnerships with governments, private companies, and startups to take advantage of India's cost-effective expertise.

II. Future Missions

After the successful conduct of the SpaDeX Mission, Prime Minister Narendra Modi, who was at the ISRO headquarters with the scientists, commented "It is a significant stepping stone for India's ambitious space missions in the years to come." This success will now enable ISRO to lay the groundwork for future autonomous docking missions like Chandrayaan-4, where India is planning on collecting samples from the

moon with two rockets that weigh over 9,000 kgs, or in the Gaganyaan Mission, where ISRO is planning on sending Indian astronauts to the moon by 2040. This mission has given India profound autonomy and an early push to build its independent space station, Bharatiya Antariksha Station, by 2035. Since the space station will have multiple units to be integrated into space, they cannot be integrated physically on Earth itself.

Currently, India is importing important source materials for satellite making, like Gallium Arsenide solar cells from the U.S., Carbon fiber-reinforced polymers from China and the U.S., and Cryogenic engine materials from Russia. But seeing growth in space start-ups and government initiatives, India is moving toward self-sufficiency in manufacturing these advanced space components, not only decreasing international dependence but also eventually transitioning from an importer to a supplier.

III. Conclusion

India's successful autonomous docking of the SpaDeX Mission is a testimony to ISRO's innovative spirit and serves as a critical foundation for its future missions, as well as to lead the growing space sector. This success is not only a technological feat but a diplomatic one to improve India's position worldwide, helping increase India's soft power, economic, and international collaborations. ISRO's groundbreaking opportunities position India as a leader in cost-effective, sustainable exploration and technological progress - autonomous docking can be used in various industries such as automation, the health sector, robotics, etc, beyond commercial use. The introduction of private companies into this sector will help expand the space sector and, in a far-reaching transition, India from a technology importer to a self-sufficient manufacturer and then eventually a supplier. India is ready to unleash its potential as a formidable force, and in A.P.J. Abdul Kalam's words, "The sky is the limit" for India.