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Indian Space Program and its Drivers

Possible Implications for the Global Space Market

European Space
Governance
Initiative

Namrata GOSWAMI

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An Initiative on "European Space Governance"

This initiative is intended to provide analysis pertaining to the international competition in space and its impact on the European space industry as well as its governance. Through a series of publications and public events, the goal of the initiative is to raise awareness among stakeholders in the European Union about the challenges presented by the transformation of the global space industry. It is coordinated by Éric-André Martin, General Secretary of the Study Committee on Franco-German relations (Cerfa) at Ifri.

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Abstract

India has one of the oldest space programs in the world with space playing a critical role in India's national development and external power projection capability. India has launched missions to the Moon and Mars and plans to send an Indian citizen to Low Earth Orbit by 2023. The Indian space program is well known for its ability to launch cheaply to space. It is in this context that this paper explains the drivers for India's space program, that includes nationalism, entrepreneurship, and national security. The paper describes India's civilian and military space capacities and highlights the emerging Indian commercial space sector and its growing role in the Indian space economy. The paper ends by specifying the impact of the Indian space sector on the global space market and by offering some recommendations for better coordination of Indian space policy.

Résumé

L'Inde possède l'un des programmes spatiaux les plus anciens au monde. L'espace joue un rôle essentiel dans le développement national de l'Inde et sa capacité de projection de puissance. L'Inde a lancé des missions sur la Lune et sur Mars et prévoit d'envoyer un ressortissant indien en orbite terrestre basse d'ici 2023. Le programme spatial indien est connu pour sa capacité à effectuer des lancements dans l'espace à moindre coût. C'est dans ce contexte que cette note analyse les déterminants du programme spatial indien, à savoir le nationalisme, l'entrepreneuriat et la sécurité nationale. Cette note décrit les capacités spatiales civiles et militaires de l'Inde et met en évidence le rôle croissant du secteur spatial commercial indien dans l'économie spatiale indienne. Elle conclut en évaluant l'impact du secteur spatial indien sur le marché spatial mondial et en proposant quelques recommandations pour une meilleure coordination de la politique spatiale indienne.

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Introduction

India is a major spacepower in Asia with global implications. This investment in space is helped by India's economic growth, currently, a two trillion-dollar economy,[1] with aspirations to become a five trillion-dollar ($) economy by 2024-2025.[2] India invests approximately $1.8 billion in space annually, helped by its low labor and manufacturing costs and low-cost launches.[3] In fact the ability to launch missions cheaply had been the Indian Space Research Organisation (ISRO)'s unique selling proposition, challenged now by reusable cheap launch capacities developed by SpaceX and Blue Origin. Consequently, India is starting to invest in its own commercial sector, to include setting up a New Space India Ltd (NSIL) and the Indian National Space Promotion and Authorisation Centre (IN–SPACe) to encourage India's commercial space sector to become globally competitive.[4]

India's space capacity includes indigenous launch capacity, sending an orbiter to the Moon and Mars, satellite launches to multiple orbits and a national security space infrastructure. In 2019, India came close to landing a probe near the South Pole of the Moon and tested an Anti-Satellite (ASAT) weapon. By 2023, India intends to send its first human mission to Low Earth Orbit (LEO). By 2030, India plans to develop its own independent space station.

This paper elucidates the drivers for India's space program. After a brief historical sketch, the paper offers an explanation of what drives India to invest in space, and what are its space capacities till date. The paper highlights the emerging Indian commercial space sector and their growing role in the Indian space economy. The paper ends by specifying the impact of the Indian space sector on the global space market and space power projection globally.

1. "GDP (Current US $) India", The World Bank, available at: https://data.worldbank.org.
2. "India Ushering in Rapid Structural Reforms to Become $5trillion Economy by 2025: Goyal," *The Hindu*, January 9, 2021, available at: www.thehindu.com.
3. C. Kumar, "India Space Spends Improves Marginally, Still Lags China, U.S.," *The Times of India*, January 29, 2021, available at: https://timesofindia.indiatimes.com.
4. P. Gill, "ISRO Will Transform in 2021 as India Pumps Big Money to Draw in Startups for the 'Second Space Age'", *Business Insider*, February 4, 2021, available at: www.businessinsider.in.

Brief Historical Sketch of India's Space Program

India is one of the oldest space nations in Asia. It established the ISRO in 1969, and launched its first satellite, the *Aryabhatta*, on a Soviet rocket in 1975. In 1972, India established the Department of Space (DoS) under the Prime Minister's Office and constituted the Space Commission. The father of the Indian space program, Dr. Vikram Sarabhai, specified why he believed India should be investing in space. According to Sarabhai, space played a critical role in a nation's national development and led to scientific progress, something India could not but invest in for its overall national development. Sarabhai stated:

> "There are some who question the relevance of space activities in a developing nation. To us, there is no ambiguity of purpose. We do not have the fantasy of competing with the economically advanced nations in the exploration of the Moon or the planets or manned spaceflight. But we are convinced that if we are to play a meaningful role nationally, and in the community of nations, we must be second to none in the application of advanced technologies to the real problems of man and society."[5]

Sarabhai was supported in his advocacy for space by Homi Bhabha, the father of India's nuclear program. The first rocket launch center was established at Thumba near Thiruvananthapuram on the coast of the Arabian sea, based on its proximity to the equator. In 1980, India successfully launched its first rocket Space Launch Vehicle (SLV)-3,[6] with a capacity to place 40 kgs, into LEO. The SLV-3 program made a critical contribution in further development of India's launch vehicle capacity.[7]

As on date, ISRO has launched 82 launch missions, to include 112 spacecrafts, and two re-entry missions.[8]

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5. Department of Space Indian Space Research Organisation "Dr. Vikram Ambalal Sarabhai," available at: www.isro.gov.in; G. Singh, *The Indian Space Programme: India's Incredible Journey from the Third World towards the First*, New Delhi: Astrotalkuk Publications, 2017.
6. V. P. Sandlas, *The Leapfroggers: An Inside Account of ISRO*, New Delhi: HarperCollins, 2018.
7. Department of Space Indian Space Research Organisation "Genesis," available at: www.isro.gov.in; also see A. Lele, *Institutions that Shaped Modern India: ISRO*, New Delhi: Rupa, 2021.
8. Department of Space Indian Space Research Organisation, "Missions", available at: www.isro.gov.in.

Drivers of India's Space Program

India's space program has completed 53 years in 2022, and has been informed by three basic drivers. These are Driver 1: Nationalism; Driver 2: Entrepreneurship, and Driver 3: National Security. These main drivers can be further sub-divided into several components informing the core genesis of India's space program. Let's delve into each driver and their sub-components.

Driver 1: Nationalism

Indians take great pride in their space program. When in 2014, India's *Mangalyaan* Mars mission entered Mars orbit, there were celebrations on the streets with a sense of accomplishment, well documented in popular culture via the movie *Mission Mangal*. Space accomplishments are viewed as demonstrating India's prowess as a technological power and adds to its prestige at the global stage. It adds to a sense of nationalism. Within nationalism are four sub-components that are worth understanding. These include nation building, regime legitimacy, internal national development, and external status.

Nation Building

Since India became independent in 1947 from British colonial rule, there has been a push to develop the scientific temper for nation building. Space was and is viewed as one such technology for critical infrastructure. Early on, under Jawaharlal Nehru, India's first Prime Minister, development of space capacity was viewed as a priority for nation building. His focus on science was further enhanced by Indian scientists like Sarabhai and Homi Bhabha, writing a letter to Nehru on the importance of space for nation building, which led to the establishment of the Indian National Committee for Space Research (INCOSPAR) in 1962, later renamed ISRO.[9] This perspective has been carried forward by later day Prime Ministers, to include current Prime Minister Narendra Modi who views space as an

9. A. Shah, "Nehru's Belief in Science Fueled India's Audacious Space Programme," *The Print*, November 14, 2017, available at https://theprint.in; E. Sadeh, "Dynamics of the Indian Space Programme: Doctrine, Power, Strategy, Security, Policy, Law, Commercialization, and Technology", *Astropolitics*, Vol. 14, No. 2-3, 2016, pp. 101-103.

important component of India's space power projection capacity and nation building.[10]

Regime Legitimacy

Space achievements result in regime legitimacy. Every prime minister liked to take credit for India's space achievements.[11] Nehru believed it was his scientific temper that led to India's space achievement thereby adding to the legitimacy of democratic India. This perspective was followed by Lal Bahadur Shastri and Nehru's daughter and India's first female prime minister Indira Gandhi. It was under Gandhi's leadership that India launched its first indigenous SLS-3 with a cost of $25.25 million. Gandhi in a speech to a joyous Indian parliament stated, "This is a great day for India and for Indian science".[12] It was during her tenure as prime minister that the first Indian [former Indian Air Force Officer, Wing Commander Rakesh Sharma] went to LEO in 1984 aboard a Soviet rocket.[13] Gandhi showcased that as an achievement of her administration. Space has continued to play a critical role in the shaping of achievements of current Prime Minister Modi, with him highlighting the importance of space for India's national development, and personally launching space reforms and developing India's commercial space sector.

Internal National Development

For India, space has played a critical role in internal national development to include Satellite Instructional Television Experiment (SITE) for developmental purposes, e-education. India developed the Satellite Telecommunication Experiments Project (STEP) to build the country's communication capabilities, viewed as a precursor to Indian National Satellite System (INSAT) supported by nine operational communication satellite placed in Geostationary orbit.[14] Space offers weather forecasting that helps crop yield, agriculture, fishery as well as early warning for natural disasters like cyclones. Space is also instrumental in maintaining e-commerce, e-banking, telemedicine and tele education. Indian private companies are planning on developing satellite constellations that could

10. "India to Become World Hub for Satellite Launches, Space Components, Modi," *The Tribune*, October 12, 2021, available at: www.tribuneindia.com; S. Vijayasekhera Reddy, " India's Forays into Space: Evolution of India's Space Programme," *International Studies*, Vol. 45, No. 3, 2008, pp. 215-245.
11. A. Siddique, "Another Global History of Science: Making Space for China and India", BJHS, Vol. 1, 2016, pp. 115-143, available at: www.cambridge.org.
12. S. Auerbach, "India Becomes Sixth Country to Put Satellite into Orbit," *The Washington Post*, July 19, 1980, available at: www.washingtonpost.com.
13. "Conversations between Indira Gandhi and Rakesh Sharma", YouTube, May 9, 2017, available at: www.youtube.com.
14. Department of Space Indian Space Research Organisation, "Communication Satellites," available at: www.isro.gov.in.

support satellite internet services to remote areas not serviced by fiber internet services.

External Status

India has tied the investment of its space program on the external status it brings. India is hailed as being able to develop low-cost launch systems (Modi is fond of boasting that India's Mars mission cost less than the making of the movie *Gravity*),[15] or that India became the first Asian nation to reach Mars in 2014. ISRO enjoyed the distinction of launching the largest number of satellites (104) to orbit in 2017; a record now broken by SpaceX's launch of 143 satellites in a single launch in January 2021. Such external status, recognition of India's space capacities by other nations matters and is one of the major drivers for India's nationalistic space program where indigenous capacity building matter to the extent that falling behind in a particular capacity is deemed acceptable.

Driver 2: Entrepreneurship

India aspires to play an entrepreneurial role in space capacity building. In 1992, India developed the commercial arm of ISRO, Antrix Corporation, for building a global customer base for Indian space technology.[16] The mission of Antrix is to identify technologies that have marketability, and to accelerate 'commercial and technical partnership' with private industry. India has strived to develop public-private partnership by establishing the NSIL in 2019, to coordinate the new space sector in India.[17] In October 2021, the Indian Space Association (ISpA) was launched by Modi to promote space technology. In his speech, Modi highlighted that the Indian government's approach to space reform was based on developing freedom of innovation in the private sector; the role of the government as an enabler and identifying the space sector as a resource for progress.[18] Modi went on to state that "the space sector is a major medium for the progress of 130 crore countrymen. For India, the space sector means better mapping, imaging, and connectivity facilities for the common people. Also, the space sector means better speed from shipment to delivery for entrepreneurs. It also means better security and income for fishermen and better forecasts of natural calamities."[19] ISRO's Indian Regional Navigation Satellite System or NavIC is offering accurate position system to users in India and the Asia

15. S. Dutta, "These Numbers Capture India's Historic and Incredibly Frugal Mars Mission," *Quartz*, September 24, 2014, available at: https://qz.com.
16. Antrix, available at: www.antrix.co.in.
17. New Space India Ltd, available at: www.nsilindia.co.in
18. "PM Modi Launches India's First Private Space Association", *The Hindustan Times*, October 12, 2021, available at: www.hindustantimes.com.
19. *Ibid*.

Pacific Region.[20] The growth of the private sector or 'Newspace' in India has risen exponentially in the last few years bringing about many of the regulatory and space sector reforms in India. Entrepreneurship, especially a motive to profit from a $400 billion space industry is becoming an increasingly powerful space driver for India.

Driver 3: National Security

The critical role that space plays in Nuclear Command, Control and Communication (NC3), military command and control, Global Positioning System (GPS), Positioning, Navigation, Timing (PNT), Intelligence, Surveillance and Reconnaissance (ISR) is now recognized by India as an important driver for investing in its space program. Consequently, India has developed its own navigation system, developed ISR capacities by launching its own military satellites and established a Defense Space Agency in 2019 to coordinate military space activities. In March 2019, India tested an ASAT weapon in order to showcase its counter space capacity as a credible deterrent to adversarial counter space capacity.[21]

Two of the major subcomponents informing the development of India's national security space infrastructure is the growing development of China's space infrastructure and Pakistan's missile development with direct strategic implications for India's border areas. China's usage of its ISR capacities in its border conflicts with India in the Ladakh sector in the west and Arunachal Pradesh in the east has meant a growing rationale within India to develop its own ISR capabilities and augment its CnC. China has built airports and deployed long range strategic bombers like the H-6K near the disputed China-India border, supported by China's military space capacity like PNT and targeting of India's border assets.[22] Satellite images reveal that China is developing and hardening its airports at Kashgar, Hotan, Ngari Gunsa, Shigatse, Lhasa Gongkar, Nyingchi and Chamdo Pangta.[23] Given the Line of Actual Control (LAC) between China and India is located in the higher Himalayas, difficult to monitor by human intelligence (HUMINT), the development of an 'eye in the sky" or satellite surveillance adds to strategic forecasting and mapping of any intrusions and/or the building of military infrastructure across the border in disputed areas. In May 2020, utilizing such satellite-based support, the People's Liberation Army crossed over to the Galwan river valley on the Indian side

20. Department of Space Indian Space Research Organisation "IRNSS", available at: www.isro.gov.in.
21. D. Peri, "Two Years since ASAT Test, DRDO Working on Several Key Technologies", *The Hindu*, March 26, 2021, available at: www.thehindu.com.
22. M. Chan, "China Sends Long Range Bomber to Border with India", *South China Morning Post*, November 16, 2021, available at: www.scmp.com.
23. M. Negi, "China Developing New Airbase in Shakche near Ladakh, India Watching Closely | Exclusive", *India Today*, July 19, 2021, available at: www.indiatoday.in.

of the LAC, resulting in a India-China border skirmish and the death of 20 Indian soldiers and an undisclosed number of Chinese soldiers.[24] China claims the entire state of Arunachal Pradesh in India, as well as the Aksai Chin region. The rise of China and its growing assertiveness in the Indo-Pacific region has resulted in the development of the Quadrilateral Security Dialogue or the QUAD between the U.S., Australia, Japan and India which includes space cooperation.[25] The second major sub-component for the development of India's national security space infrastructure is the border dispute between India and Pakistan across the Line of Control (LoC) in Kashmir, and cross-border terrorism that is a continuous feature of that disputed border. Pakistan's growing missile capacity and the Kashmir dispute implies the need for India to develop its satellite based ISR, as well as strengthen its NC3.

India's Space Vision

The drivers for India's investment in space locates the 2025 vision in context. The ISRO *Vision 2025 plan* put out by the Vikram Sarabhai Space Centre (VSSC), identifies the following future space goals.

1. To develop satellite-based communication and navigation systems for rural connectivity, security needs, and mobile services.
2. To enhance imaging capability for the management of natural resources, weather and assist in climate change studies.
3. To further develop 'space science' missions to enhance understanding of the solar system and the universe.
4. To develop a heavy lift launcher capability.
5. To develop Reusable Launch Vehicles.
6. To develop a human flight program.[26]

India intends to develop an overall space capacity that includes civilian, commercial and military components specifically driven by the core drivers of nationalism, entrepreneurship, and national security.[27] The next section highlights some of the capacities that India is building across its civilian, military, and commercial space.

24. "India-China Clash-20 Indian Troops Killed in Ladakh Fighting", BBC, June 16, 2020, available at: www.bbc.com.
25. "Fact Sheet: QUAD Leaders' Summit", The White House, September 24, 2021, available at: www.whitehouse.gov.
26. N. Goswami and P. Garretson, *Scramble for the Skies The Great Power Competition to*, Lanham: Lexington Press, 2020, p. 237.
27. N. Goswami, "India's Space Program, Ambitions and Activities", *Asia Policy, National Bureau of Asian Research,* Vol. 15, No. 2, April 2020, pp. 43-49, available at: https://muse.jhu.edu.

Civilian Space Capacity

The Indian space program is led by the DoS that falls under the Prime Minister's Office under which is ISRO, the main space government organization in India. India has developed indigenous launch capacity that includes the Polar Satellite Launch Vehicle (PSLV), the Geosynchronous Satellite Launch Vehicle (GSLV). The PSLV continues to be major launch vehicle functional since 1993 with a capacity to lift 1,750 kg to Sun Synchronous Orbit (SSO) to a height of 600 kms and 1,425 kg to Geosynchronous Transfer Orbit (GTO). The PSLV launched India's first Moon mission (*Chandrayaan* 1 in 2008) and first Mars mission (*Mangalyaan* in 2013).[28] The GSLV Mark III is India's heavy lift rocket, with a cryogenic upper stage that lifts 8,000 kg to LEO and 4,000 kg to GTO. The GSLV Mk III launched India's second mission, *Chandrayaan* 2 in 2019, successfully inserting the mission into Earth's parking orbit for lunar orbital transfer.[29] Besides holding the record for launching the highest number of satellites till January of 2021, ISRO launched 29 satellites into three different orbits in 2019.[30] India has a total of approximately 33 civilian satellites in orbit launched since 1975. Of the civilian fleet of satellites, the most numerous are the INSAT (Indian National Satellite System) series of 11 operational satellites, first launched in 1983, aimed at broadcasting, meteorology, search and rescue, and telecommunications. INSAT is a joint venture of the DoS, Department of Telecommunications, India Meteorological Department, All India Radio and Doordarshan [India's main TV broadcaster]. The INSAT Coordination Committee is the apex body that helps coordinate the data generated by INSAT. The INSAT is supported by the GSAT (Geostationary satellites) of which there are 10. The GSAT-30, the latest in the series was launched in January 2020, from Kourou launch base, French Guiana by Ariane-5 VA-251.[31] The GSAT-30 delivers communications from GEO. India's NavIC system that extends positioning services across the Asia-Pacific aims at offering "Terrestrial, Aerial and Marine Navigation, Disaster Management, Vehicle tracking and fleet management, Integration with mobile phones, Precise Timing,

28. Department of Space Indian Space Research Organisation "Polar Satellite Launch Vehicle", www.isro.gov.in.
29. Department of Space Indian Space Research Organisation, "GSLV Mk III", available at: www.isro.gov.in.
30. Indian Express, "Explained: What makes PSLV-C45 special," April 2, 2019, available at: https://indianexpress.com.
31. Department of Space Indian Space Research Organisation, "GSAT-30", available at: www.isro.gov.in.

Mapping and Geodetic data capture, Terrestrial navigation aid for hikers and travellers, and Visual and voice navigation for drivers".[32]

India has demonstrated capability to enter both lunar and Mars orbit with its *Chandrayaan* lunar mission and Mars mission. It was NASA's Minerology Mapper (MP3) aboard *Chandrayaan 1* that detected water on the lunar surface in 2008.[33] In 2014, India became the first Asian country to enter Mars orbit, a feat that led to a heightened sense of nationalism. In August 2019, its *Chandrayaan* 2 mission successfully entered lunar orbit and placed an orbiter there to map the lunar poles.[34] However, India's attempt to soft-land on the lunar South Pole was not successful, failing to land in the last few seconds. In January 2020, ISRO Chairperson, K. Sivan announced that India will attempt to soft land on the lunar surface via its *Chandrayaan* 3 mission utilizing data from the *Chandrayaan* 2 orbiter that will remain active for seven years (2019-2026).[35] India signed an Implementation Agreement and a Memorandum of Understanding (MoU) with Japan to collaborate on the *Chandrayaan* 3 mission (launch date 2022) and the Lunar Polar Exploration Mission (LPEM). The aim of LPEM is to send a rover and a lander to the lunar south pole by 2024 in order to prospect for water ice.[36] India has announced a second Mars mission aimed at putting another orbiter, after the *Chandrayaan* 3 mission, as per ISRO Chairperson K. Sivan.[37] India has announced a mission to Venus called *Shukrayaan* 1 to study the planet by 2024 as well as a mission called *Aditya* L1 to study the sun. ISRO explains that the *Aditya* L1 satellite will be inserted into the Earth-Sun's Lagrange 1-L1 (1.5 million kms) from Earth as it offers advantages of continuous viewing without any eclipses. ISRO specifies that "Aditya-L1 with additional experiments can now provide observations of Sun's Corona (soft and hard X-ray, Emission lines in the visible and NIR), Chromosphere (UV) and photosphere (broadband filters). In addition, particle payloads will study the particle flux emanating from the Sun and reaching the L1 orbit, and the magnetometer payload will measure the variation in magnetic field strength at the halo orbit around L1."[38] In August 2018, Prime Minister Narendra Modi announced that India

32. Department of Space Indian Space Research Organisation "IRNSS", *op. cit.*
33. NASA HQ, "NASA Rader Finds Ice Deposits at Moon's North Pole; Additional Evidence of Water Activity on Moon," SpaceRef, March 1, 2010, available at: www.spaceref.com.
34. J. Davis, "Chandrayaan-2 Enters Lunar Orbit", *The Planetary Society*, August 20, 2019, available at: www.planetary.org.
35. "India to Take another Shot at Moon Landing after Crash Last Year", *The Japan Times*, January 2, 2020, available at: www.japantimes.co.jp.
36. A. Jones, "Japan, India Set to Resume Launch Activities in November," SpaceNews, October 14, 2020, available at: https://spacenews.com.
37. "ISRO Chief Says India's Second Mars Mission Mangalyaan 2 will be an Orbiter Mission," *India Today*, February 20, 2021, available at: www.indiatoday.in.
38. Department of Space Indian Space Research Organisation, "Aditya – L1 First Indian Mission to Study the Sun," available at: www.isro.gov.in.

would send a man or woman into space by 2022 [now revised to 2023][39] in a mission called *Gaganyaan*.[40] Indian astronauts (Indian Air Force Officers) trained for the mission for a year at the Gagarin Cosmonaut Training Center.[41] In 2019, India announced its intention to launch its own space station by 2030.[42] Based on an assessment of India's civilian capacity, it is clear that India aims to become an efficient space nation and views space as critical to its national and international standing. In 2021, despite the impact of Covid-19, India space budget increased by 3.5 per cent with a focus on developing its private space sector with funds earlier allocated to the DoS now sent to NSIL, the government body that can authorize funds for the private space sector.[43] This is strategically consequential development given the role of the private space sector in the U.S. bringing down the cost of access to space.

39. S. Singh, "Covid Stalled Gaganyaan Project, Manned Mission Will Likely Be Launched by 2023", *The Times of India*, November 11, 2021, available at: https://timesofindia.indiatimes.com.
40. "Gaganyaan, India's First Manned Mission, Set to Be a Reality by 2022," Live Mint, August 15, 2018, accessed June 13, 2019, available at: www.livemint.com.
41. ANI, "4 Indian Astronaut Candidates for Gaganyaan Mission Complete Training in Russia," *Hindustan Times*, March 23, 2021, available at: www.hindustantimes.com.
42. P. Bagla, "NDTV, "India Planning to Launch Own Space Station by 2030, Says ISRO Chief K Sivan," June 13, 2019, available at: www.ndtv.com.
43. P. Gill, "ISRO Will Transform in 2021 as India Pumps Big Money to Draw in Startups for the 'Second Space Age'", *op. cit.*; also see C. R. Rajamohan, "India's Space Program Inches Closer to the U.S. and the Quad", *Foreign Policy*, October 13, 2021, available at: https://foreignpolicy.com.

Military Space Capacity

In 2021-2022, India's defense budget was $49.6 billion of which $18.4 billion was allocated for procurement of weapons. Within this budget is allocated expenditure for space systems like satellite procurement for the Air Force, without specific amounts being allocated. India's Defence Research and Development Organisation (DRDO) had been at the forefront of advocating for hypersonic launch vehicle, small Inter Continental Ballistic Missiles, and ASAT capability with capacity to strike both LEO and Geosynchronous Orbit (GEO). Since 2000, India has invested in its military space capacity especially investing in developing high resolution satellites for tactical military operations and to generate ISR. A reason for this was due to major intelligence failure during the Kargil War in 1999 when Indian intelligence failed a timely detection of Pakistani intrusion into Kargil.[44] The Technology Experimental Satellite (TES) launched in 2001 was India's first military application satellite. In 2004, India established the National Technical Research Organisation (NTRO) as the institution to monitor ISR, and unmanned aerial vehicles (UAVs).[45] India has about 15 military application satellites with the G-SAT 7 (INSAT 4F) dedicated to the Indian Air Force but is shared by the Indian Army. The need for higher resolution imagery especially along the disputed China-India border is of priority. India is developing capability across Signal Intelligence (SIGINT), Communication Intelligence (COMINT) and Electronic Intelligence (ELINT).[46] The geopolitical aspect of China's enhanced military and counterspace capacities are informing India's strategic decision making. The contribution of satellites to Space Situational Awareness (SSA), ISR, CnC have formed important components of India's decision to establish a Space Security Coordination Group (SSCG) in 2010 chaired by its National Security Advisor, and in 2019, a Defense Space Agency and a center dedicated to development of military space capacities within DRDO.[47] While the U.S. and China far outpace India when it comes to military space capabilities, India is waking up to that critical dimension of SSA and ISR space-based support. The issue here is that given the very limited military satellite support, India would have to develop capacity to rapidly replace its

44. V. Raghuvanshi, "Indian Aerospace Command to Operate Military Satellites," *SpaceNews*, April 4, 2005, accessed June 11, 2019, available at: https://spacenews.com.
45. J. Bajoria, "RAW: India's External Intelligence Agency," CFR, November 7, 2008, available at: www.cfr.org.
46. M. Negi, "India Enhancing Military Capabilities in Space with New Censors, Satellites", *India Today*, March 26, 2021, available at: www.indiatoday.in.
47. V. Raghuvansi, "India to Launch a Defense-based Space Research Agency", *DefenseNews*, June 12, 2019, available at: www.defensenews.com.

satellites in the event of adversarial destruction, jamming or disabling of any of its satellite support system. In 2022, the Indian Navy will get its own communication satellite GSAT-7R built by ISRO at a cost of $225 million. Such dedicated satellites (for the Indian military) enable communication between their warships, drones, aircrafts, and ground units. During the U.S.-India 2+2 Ministerial Dialogue in October 2020, India and the U.S. signed a deal by which India would get access to U.S. satellite data that helped missile targeting as part of the Basic Exchange and Cooperation Agreement.[48] India's geopolitical interest expands to the Indian Ocean and the Malacca Straits through which its import of oil from the Persian Gulf flows. Hence the requirement for a military satellite for the Indian navy.

In March 2019, India tested an ASAT weapon termed *Mission Shakti* against the target Microsat-R. The test was executed in a manner to minimize long-lasting debris. The RAND report on *Responsible Space Behavior for the New Space Era: Preserving the Province of Humanity* stated that "in March 2019, an Indian ASAT test generated approximately 400 fragments that will decay in weeks or perhaps a few months because the target was orbiting at less than 300 km. As of the end of 2019, less than 20 pieces of the debris created from the Indian ASAT test earlier that year remained on orbit".[49] Immediately after the test, the DRDO released a detailed video explaining the test.[50] Modi described India's ASAT test as firmly establishing India as a military spacepower. The critical driver of regime legitimacy, external status and national security were all intertwined in that framing. Modi stated, "India has made an unprecedented achievement today... India registered its name as a space power."[51] He tweeted "in the journey of every nation there are moments that bring utmost pride and have a historic impact on generations to come. India has successfully tested the Anti-Satellite (ASAT) Missile".[52] The ASAT test can be interpreted as a response to China's ASAT test in 2007 and the continued development of its counter space capacity like RPOs as well as the establishment of the People's Liberation Army Strategic Support Force (PLASSF) in 2015.[53] In 2020, the U.S. Congress in its National Defense Authorization Act designated the Indian NaVIC global navigation satellite system (GNSS) as an allied system after such a designation from the

48. S. Roy Choudhury, "India Will Get Access to U.S. Satellite Data That Can Make Military Missiles More Precise", CNBC, October 27, 2020, available at: www.cnbc.com.
49. B. McClintock, K. Feistel, D. C. Ligor and K. O'Connor, *Responsible Space Behavior for the New Space Era: Preserving the Province of Humanity,* Santa Monica, CA: RAND Corporation, 2021, pp. 17-18, available at: www.rand.org.
50. DRDO, Official video on Mission Shakti (Project XSV1), Youtube, April 6, 2019, available at: www.youtube.com.
51. "Indian PM Modi Boasts Success of Anti-Satellite Launch Ahead of Election", *NBC News*, March 27, 2019, available at: www.nbcnews.com.
52. @narendramodi, available at: https://twitter.com.
53. "PLA Strategic Support Force formation debuts in National Day parade", *Xinhua*, October 1, 2019, available at: www.xinhuanet.com.

Secretary of Defense in consultation with the Director of National Intelligence.[54] In September 2020, India tested an indigenous hypersonic demonstrator vehicle powered by a scramjet engine. This test vehicle could move at six times the speed of sound and built by DRDO.[55] Interestingly, France and India have agreed to a bilateral space security dialogue in August 2021, India becoming the first Asian country with whom France has agreed to hold such a consultation. India has such space security dialogues with two other countries, the U.S. and Japan.[56]

54. S.1790 – National Defense Authorization Act for Fiscal Year 2020, available at: www.congress.gov.
55. V. Raghuvanshi, "Watch India Test Its New Homemade Hypersonic Vehicle", *Defense News*, September 9, 2020, available at: www.defensenews.com.
56. S. Sibal, "India, France to Launch Space Security Dialogue to Protect Space Asset", August 8, 2021, available at: www.wionews.com.

Commercial Space Capacities

The rise of the commercial space sector in India is a new phenomenon. This has been led by companies like Team Indus, who were finalist at the GOOGLELUNARXPRIZE, but bowed out in the final months due to lack of funds. In fact, none of the five finalists were able to claim the $30 million prize. In a statement, the X Prize organizers stated that "This literal 'moonshot' is hard, and while we did expect a winner by now, due to the difficulties of fundraising, technical and regulatory challenges, the grand prize of the $30M Google Lunar XPRIZE will go unclaimed."[57] Team Indus however played a critical role in galvanizing the "newspace' sector in India. In response to the development of a vibrant space commercial sector, India established a NSIL in 2019 in order to build a platform for Indian space industry to sell their products to a global clientele.[58] This shift for India from being a state driven space nation to becoming more open and privatized was observed when a large amount of the space budget 2021-2022 [Indian Rupees 700 crore] was allocated to NSIL, with ISRO adopting the role of a facilitator for space innovation. NSIL now has the authority to solicit participation of the private sector directly.[59] Discussions are on to enable the Indian private sector to manufacture rockets, once the sole domain of ISRO. This in turn creates and supports the development of a private space sector generating employment, as well as retention of talent since not all who want to work in the space sector can get jobs at ISRO. In October 2021, Modi launched ISpA billed as the premier space institution for space and satellite companies. Modi stated on its foundation:

> "Today is the day the Indian space sector receives new wings. For 75 years since independence, Indian space has been dominated by a single umbrella of Indian government and government institutions. Scientists of India have made huge achievements in these decades, but the need of the hour is that there should be no restrictions on Indian talent, whether it is in the public sector or in the private sector. In a way, the country has given a new gift to the talent of India's entrepreneurs by opening up India's space sector in its 75th year of independence. Let this collective power of India's population take the space sector forward in an organized manner. The Indian Space Association (ISpA) will play a huge role in this.[60]

57. "$30mn Google Lunar XPRIZE Dream Ends for 5 Teams, Including India's Team Indus", *The Hindustan Times*, January 24, 2018, available at: www.hindustantimes.com.
58. New Space India Ltd, available at: www.nsilindia.co.in.
59. P. Gill, *op. cit.*
60. Department of Space Indian Space Research Organisation, "Hon'ble PM Shri Narendra Modi Launches the Indian Space Association (ISpA)", available at: www.isro.gov.in.

ISpA includes, besides ISRO representatives, several key private sector companies like Bharti Airtel, Larson & Toubro, Nelco (Tata Group), OneWeb, Mapmyindia, Walchandnagar Industries, Alpha Design Technologies, Godrej, Hughes India, Ananth Technology Limited, Azista-BST Aerospace Private Limited, BEL, Centum Electronics, Maxar India, etc.[61] The aim of ISpA is to turn India into a global leader in the space economy by harnessing both talent and resources from the private sector, and build public-private partnerships in space, not dissimilar to the success of public-private partnerships in space in the U.S. that has resulted in companies like *Blue Origin* and *SpaceX*; global leaders in reusable technology. India also set up an organization called Indian National Space Promotion and Authorization Centre (IN-SPACe) in 2020, billed as "an independent nodal agency under Department of Space for allowing space activities and usage of DOS [Department of Space] owned facilities by Non-Government-Private-Entities (NGPEs) as well as to prioritise the launch manifest."[62] IN-SPACe will offer a single window overseeing body for private sector rocket building and launch permits, share ISRO launch sites and offer temporary office space, and develop a new space infrastructure ecosystem.[63] These developments in the commercial space sector in India are indeed consequential especially due to the historical relationship between ISRO and private space companies viewed as suppliers to ISRO, not entities that could launch to space or build rockets in their own right. Indian commercial space sector has at best been neglected to the detriment of entrepreneurship and retention of talent with several newspace entrepreneurs preferring to incorporate in other countries due to India's state heavy opaque laws and clear guarding of turf by ISRO. The establishment of institutions like NSIL, IN-SPACe and ISpA signal that private space companies especially the 'newspace' entrepreneurs have succeeded in informing the Indian government decision to reform and open up the space sector to private entrepreneurship. Critically for capacity building, the Indian commercial companies will now be able to utilize space facilities owned by DoS. Another shift in Indian space thinking is evident from the fact that the Chairperson on IN-SPACe was not selected from an ISRO insider as was usually the case with upper-level bureaucratic jobs but by Pawan Kumar Goenka, former Managing Director of Mahindra & Mahindra, one of India's largest automobile companies.[64] This trend of recruiting outsiders to India's space program was followed by ISRO's founder, Vikram Sarabhai and his immediate predecessor, Satish Dhawan but discarded after his tenure with only ISRO insiders getting the top jobs.

61. *Ibid*.
62. Indian National Space Promotion and Authorization Center (IN-SPACe). ISRO, available at: www.isro.gov.in.
63. Roles and Responsibilities. ISRO, available at: www.isro.gov.in.
64. "Ex-M&M MD Pawan Goenka Named Chairperson of Space Regulator IN-SPACe", *Business Today*, September 21, 2021, available at: www.businesstoday.in.

The establishment of ISpA implies that now the private sector has one organization that they can utilize to help navigate India's difficult regulatory environment. While NSIL can solicit participation of the private sector directly, IN-SPACe can grant usage of DOS owned facilities by NGPEs or private space companies. ISpA will be the "apex space industry body" advocating for private space companies, and "undertake policy advocacy and engage with all stakeholders of the entire Indian space domain, including the government and its agencies, to make India self-reliant, technologically advanced and a leading player in the global space arena."

Amongst the newspace companies of note in India are Astrome,[65] Bellatrix Aerospace,[66] Earth2Orbit,[67] Exseed Space,[68] ReBeam,[69] Satsure,[70] Skyroot Aerospace, SmartEnovations.[71] Bellatrix Aerospace is developing a rocket propulsion system, aspiring to build a small launch vehicle and is the first company to be offered a contract with ISRO.[72] Bellatrix has also raised about $3 million in funding becoming the first Indian startup to accomplish that.[73] This funding will be utilized to demonstrate its thruster technology specifically its electric propulsion system that runs on water.[74] In February 2021, Bellatrix and Skyroot Aerospace signed a Memorandum of Understanding (MoU) to build a vehicle termed a 'space taxi' aimed at offering ridesharing for small satellites and dropping each satellite to its orbit.[75] Skyroot Aerospace is building India's first private rocket, the *Vikram I* and have successfully tested its upper stage engine *Raman* and Solid fuel demonstrator *Kalam-5* in 2020.[76] Satsure aims to utilize space systems towards building sustainable eco systems.[77] Sature and Bellatrix signed an MoU early 2021 to power its fleet of remote sensing satellites. Astrome seeks to develop wireless millimeter wave technology.[78] Exseed Space is the first entirely private Indian space start-up to succeed in building and launching its own satellite on an international commercial launch (a *SpaceX* Falcon 9).[79] ReBeam aims to build wireless transmission of power for technologies like Space Based Solar Power. SmartEnovations is

65. Astrome, available at: www.astrome.co.
66. Bellatrix Aerospace Website, available at: www.bellatrixaerospace.com.
67. Earth2Orbit Website, available at: www.earth2orbit.com.
68. Exseed Space Website, available at: www.exseedspace.com.
69. ReBeam Website, available at: https://nopo.in.
70. Satsure Website, available at: www.satsure.in.
71. Smart Enovations Website, available at: www.smartenovations.com.
72. Bellatrix Aerospace Website, available at: www.bellatrixaerospace.com.
73. C. Henry, "Indian Startup Bellatrix Aerospace Raises $3 million", Spacenews, June 21, 2019, available at: https://spacenews.com.
74. *Ibid*.
75. "Space Taxi for Satellites? Two Indian Startups Sign Pact to Build Vehicle" *Business Today*, February 9, 2021, available at: www.businesstoday.in.
76. Skyroot Aerospace. Vikram Series, available at: https://skyroot.in.
77. SatSure, available at: https://satsure.co.
78. Astrome, available at: https://astrome.co.
79. S. Singh and S. Laxman, "India's First Private Satellite Launched", *The Times of India*, December 5, 2018, available at: https://timesofindia.indiatimes.com.

focused on developing space systems to include virtual testing, simulation and validation.[80] Earth2Orbit aspires to support global climate action using space data analytics.[81] Pixxel India is planning to launch a constellation of Earth imaging satellites aimed at monitoring every part of the globe, and beam back high-resolution imagery useful for urban planning, agriculture and monitoring climate change.[82] However, the company could not meet its stated launch date on ISRO's PSLV C51 in March 2021 due to software issues. However, the launch of the satellite was viewed as special given it would have been India's first privately developed satellite to launch on an ISRO rocket.

80. Smart Ennovations. Space Systems, available at: www.smartenovations.com.
81. Earth2Orbit. www.earth2orbit.com.
82. A. Singh, "Explained: ISRO's PSLV C51 Launch and Why Pixxel India's Anand Satellite Missed that Flight", *The Indian Express*, March 4, 2021, available at: https://indianexpress.com.

India's Impact on the Global Space Economy and Concluding Thoughts

India is a major power in space and one of the foremost economic players in the world today. According to a PricewaterhouseCoopers report on the *World in 2050*, India is forecasted to emerge as the second largest economy in GDP (Purchasing Power Parity-PPP) by 2050 overtaking the U.S. (3) and behind China (1).[83] That said, India's contribution to the $400 billion global space economy stands at a meagre two percent. ISRO forecasts that by 2030, that share could go up to 9 per cent given the current focus on privatization and public private partnership to develop space technology.[84] India has an advantage given its ability to launch cheaply and that could add to its attractiveness as a global space manufacturer. In order to encourage commercialization of space and due to the pressure brought about by its private space sector, India constituted its space reform mission. ISRO states that the push for space reform is critical to develop India's private sector. Reform is taking place along five anchors as specified below:

a. "In order to enhance utilization and maximize benefits from the space assets, it is proposed to change the approach from "Supply Based Model" to "Demand Based Model". NewSpace India Limited (NSIL) will act as the aggregator of user requirements and obtain commitments.

b. NSIL to take ownership from DOS for operational launch vehicles, commercialize launches, satellites, and services.

c. Permit NGPE's to carry out space activities through an Indian National Space Promotion and Authorization Center (IN-SPACe)

d. ISRO to carry out capacity building in Space domain through development of new technologies and capabilities and enable sharing of facilities by NSIL and NGPE's.

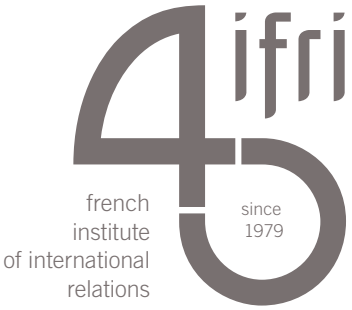
83. PricewaterhouseCoopers "World in 2050", available at: www.pwc.com.
84. Department of Space Indian Space Research Organisation, "Hon'ble PM Shri Narendra Modi Launches the Indian Space Association (ISpA)", *op. cit*. Also see A. Dasgupta, "Making Sense of the INSPACe and ISpA Jugalbandi to Expand Space Services", *The Wire*, October 14, 2021, available at: https://science.thewire.in.

e. Announcement of Opportunities for NGPE's offering challenges in new domains of technology."[85]

Given the drivers of nationalism, entrepreneurship and national security, India might require a national level space policy making body to coordinate the different aspects of space to include science and technology, space's role in critical civilian infrastructure, in military space operations. Space is no longer just limited to rocket and satellite launches with nations like China, Russia and the U.S. now viewing space more from a space resource utilization perspective, and the U.S. and China in particular galvanizing their private space sector. Chinese private company OneSpace has launched to orbit and Linkspace is developing reusable rocket technology. Galaxy space is aiming to launch 142 5G-satellites for satellite internet and communications purposes. India is lacking in this regard and has a lot of catching up to do to reach the level of regulatory environment present in the U.S. and China's funding for its private sector which has reached around $2 billion annually. India would need to institute a national space body that comprises not only the representation from DoS but also the Ministry of Defence, the Defence Space Agency, the Ministry of Home, Ministry of Environment, Forest and Climate Change and the Ministry of Agriculture since space affects all of them. Additionally, the National Security Advisor should form an integral part of it as well.

In conclusion, the Indian space program will remain a powerful expression of Indian nationalism, its way of seeking prestige globally as well as inspirational to its people. The powerful drivers of nationalism and its sub-components to include nation building, regime legitimacy, internal national development, and external status; entrepreneurship especially the role of its new commercial space sector, and national security dimensions of space including its counter space capacity will remain critical components that affect its space capacity and policy as we move forward into a second space age of lunar permanent presence, a bourgeoning space economy and space resource utilization.

85. Department of Space Indian Space Research Organisation, "Opening Up Indian Space Sector for Private Sector–Reforms", available at: www.isro.gov.in.



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