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India's Space Program
International Competition and Evolution

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Executive Summary

India's space program has grown and evolved significantly in the last five decades. The program originally focused on developing space assets that provided direct developmental benefits, for example telecommunications and remote sensing satellites that helped both in improving communication facilities and giving direct assistance to India's farmers. But over time, India has shifted a part of its focus towards space exploration and other high-profile missions that do not have as clear a developmental purpose as earlier. This includes, for example, India's Mars and Moon exploratory missions. Overall, India has been fairly successful in these efforts and its space program has become a comprehensive one that includes not only a robust launch capacity and very large remote sensing satellite systems, but also a very well rounded scientific and deep space exploratory program.

The next major step for India is a first crewed space mission, Gaganyaan, to be undertaken by 2022. This is a very ambitious target, which is important for various reasons. First and foremost, as the Indian space program evolves, this is the next logical step. While one may not see an immediate and direct economic linkage, in the longer-term, such missions are likely to bear fruit, especially in terms of the spin-off technological benefits derived from the mission. Second, Gaganyaan will add great weightage and visibility to the Indian space program, just like the Moon and Mars missions. This is an aspect that India should not shy away from emphasizing as the space security competition picks up momentum.

India's already robust program has also acquired national security overtones over the last decade. This is partly driven by India's growing technological capacity. But an important part of the reason for this change is the evolving security threats that India has faced, especially in relation with Pakistan and China. The perceived need to keep pace with the expansion of Pakistan's ballistic missile capabilities has become stronger over the years, making India much more willing to consider the utility of such weapon systems. In addition, China's first successful anti-satellite (ASAT) test in January 2007 suddenly made India's space-based assets vulnerable. India thus had to consider developing its own ASAT capability, at least as a deterrent to anybody else using ASATs against Indian assets in space.

China's achievements in space led not only to India's own ASAT program, but also to other elements that enhanced the security component of India's space program.

As the military characteristics of its space program are becoming more evident, India is also moving away from its traditional position of non-weaponisation of space to a more nuanced approach to its national space policy. While the official policy itself has not changed, India is beginning to have a much more determined approach to how it wants to protect its assets in outer space as well as its ground infrastructure and the services linked to space. One of the big shifts evident in the last decade is the development of India's military space capabilities and the establishment of the institutional architecture that supports the new functions and roles for space in India's national security calculations. In particular, India established a Defense Space Agency (DSA) in April 2019, which is expected to be the forerunner for a full-fledged aerospace command. It is also establishing a Defense Space Research Organization (DSRO), which is meant to undertake research and development on the capability mix that is required as per the strategy and policy developed by the DSA.

In a first, India conducted a space security table-top war game (called "IndSpaceEx") in late July 2019, which involved all the different stakeholders such as the military and the scientific establishment. This is is another reflection of the growing synergistic approach between space and the military. The Indian space program, thus, is being carried along not only because of its developmental needs, but also because of larger international political factors, such as the heightening international tension, great power competition and the lack of sufficient safeguards, international norms and institutions to protect the non-weaponisation of outer space.

Table of Contents

Introduction

As India becomes a more prominent player in Asia and beyond, there is a lot more at stake for the international community as to how New Delhi approaches its policy and programs with regard to a number of national security-related technologies. Outer space is one such domain where India's policy has come under the global scrutiny. Indeed, for the last decade or so, India's approach to outer space has been shifting and it is now increasingly driven by national security concerns. In so doing, India has moved away from its traditional, morally-driven policy that opposed any militarization of outer space and emphasised that outer space must be used for peaceful endeavours alone. There are good reasons for this shift: India's security concerns have grown and they now encompass outer space too. Further, technology development has provided some solutions to terrestrial security problems. Most importantly, China's rise and the competition between India and China have also driven some aspects of India's space program.

While New Delhi is yet to change its official position, there are evolutions evident on the ground, with India developing certain military characteristics to its space program. The change has been gradual, starting in the early 2000s, and it has gone back and forth between the new policy approach and the old comfortable position highlighting non-weaponisation of space. India has still not abandoned its policy of non-weaponisation, but it has felt that its inaction and ignoring of contemporary security developments in outer space could leave it vulnerable to a range of threats to its space assets. Therefore, New Delhi has managed to shed its past approach of loud criticism of outer space militarization by the US and the USSR during the Cold War, to one that is more considered and nuanced. Apart from China's rise and growing military proficiency, including in the military space program led by the People's Liberation Army (PLA), the consequences of threats from increasing anti-satellite (ASAT) missiles and other counter-space capabilities, such as electronic and cyber warfare, are pertinent developments that India cannot afford to overlook. In fact, China's first successful ASAT test in January 2007 became the single biggest determining factor driving India's new approach.

Even as India has had to be mindful and possibly confront these threats in the future, there are many in the West and elsewhere, who have questioned India's space program, especially the new features of it. Many have challenged India saying that, as a developing country, it should use its

limited resources to address its developmental challenges before pursuing a space program. But post-independence, both India's political and scientific leadership understood as to how space can significantly contribute to its development. Dr. Vikram Sarabhai, the father of the Indian space program, had stated,

> There are some who question the relevance of space activities in a developing nation. To us, there is no ambiguity of purpose. (...) 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.[1]

A second important consideration for India is its interest in shaping the global governance debates. India has continued to note that its overall technological profile will partly determine its ability to sit at the global high-table framing new rules of the road for outer space activities.

In this paper, I outline some of the changes in India's space program and policy and the factors driving them. To set the background, I begin by briefly outlining the early stage of the Indian space program. The second section describes the coming of age of this program and its shifting nature. The final section explains the more recent changes, especially the growing orientation towards security, in the Indian space program.

1. Indian Space Research Organization, www.isro.gov.in

Evolution of India's Space Program[2]

A space program primarily focused on India's development needs

India's space program has evolved substantially since it launched its first sounding rocket from Thumba, near the southern tip of the subcontinent, in 1963. In a post-independent India that had to address several important developmental challenges, India's civil space organization, the Indian Space Research Organization (ISRO) began its activities with a sole focus on using space to address the social and economic requirements of the masses. Indeed, the Sarabhai Profile, the earliest Indian program, combined both nuclear and space power, but primarily looked at the importance of these technologies for the country's economic development. Clearly, the recent interplanetary missions such as those to Mars (Mangalyaan) or to the Moon (Chandrayaan) were not part of the original goals set for the new space organization.

However, both the early political leadership, especially India's first Prime Minister Jawaharlal Nehru, and the scientific leadership, including the father of the Indian space program, Dr. Vikram Sarabhai, were clear on the significance of developing Indian technology, especially in cutting edge areas such as nuclear and space. They wanted these demonstrations of India's technological capacity also in order that they could ensure for India a seat in exclusive global political clubs. The two also understood the impact of the space technology in the national security context although this was not given any play until a decade ago. Nevertheless, the importance of space was appreciated in the context of India's security missions and that became another imperative for India to pursue its space program.

For a newly independent country with vast geography, developing effective communication was an important requirement, which pushed the ISRO to initially focus on its communication satellites. This led to the development of the Indian national satellite (INSAT) series, which is now

2. This section is adapted from Rajeswari Pillai Rajagopalan, "India's Space Ambitions and Capabilities," in: S. Ganguly, N. Blarel and M. S. Pardesi (eds.), *The Oxford Handbook of India's National Security*, Oxford: Oxford University Press, 2018.

considered one of the largest domestic multipurpose satellite systems in the Asia-Pacific. ISRO began this journey with the launch of INSAT-B in 1983 and this had a huge impact in television broadcasting, satellite newsgathering, weather forecasting, disaster warning, and search and rescue missions. The INSAT system today consists of more than 200 transponders in frequency bands such as the C, Extended C and Ku-bands.[3] India currently offers 167 transponders to broadcasters, but it has had to lease close to 100 foreign transponders to address the growing domestic demand. ISRO's communication satellite system includes 15 operational satellites of the INSAT and GSAT series (some of them multi-purpose).[4]

A second major focus area for ISRO was remote sensing or earth observation satellites, again a sector that it developed well, with services offered to both regional and global customers. India's remote sensing (IRS) satellites use state-of-the-art camera to capture images of the Earth in varied resolutions, bands and swaths.[5] India began this journey with IRS-1A, the first of the indigenously developed series that was launched into a polar sun-synchronous orbit on March 17, 1988 from the Soviet Union. Today, India boasts of having one of the largest remote sensing satellite systems in the world. Its major remote sensing satellites include thirteen operational satellites in sun-synchronous orbit (RESOURCESAT-1, -2, -2A; CARTOSAT-1, -2, -2A, -2B; RISAT-1 and 2; OCEANSAT-2; Megha-Tropiques; SARAL and SCATSAT-1) and four in geostationary orbit (INSAT-3D, Kalpana, INSAT-3A, INSAT-3DR).[6]

The other major focus area for ISRO was satellite launch vehicles, or rockets, which started in the early 1970s. India had its first successful test of a satellite launch vehicle (SLV) in July 1980. Subsequently, it went on to develop the Augmented Satellite Launch Vehicle (ASLV) for launching payloads up to 150 kg into the low earth orbit (LEO). But the ASLV was not a particular success – it had several failures and just one successful test. Meanwhile, ISRO recognised the need for a launch vehicle that would carry heavier payloads, and so phased out both the SLV and the ASLV programs. Thereafter, from the 1990s on, the ISRO went on to make tremendous progress on the launch vehicle sector with its Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Launch Vehicle (GSLV) programs. The PSLV

3. Indian Space Research Organization, "Communication Satellites," www.isro.gov.in
4. *Ibid*.
5. R. R. Navalgund, V. Jayaraman and P. S. Roy, "State of the Art Cameras: Remote Sensing Applications: An Overview," *Current Science*, Vol. 93, No. 12, December 25, 2007; R. R. Navalgund and K. Kasturirangan, "The Indian Remote Sensing Satellite: A Program Overview," *Proceedings of the Indian Academy of Sciences Section C: Engineering Sciences*, Vol. 6, No. 4, December 1983, pp. 313-336.
6. Indian Space Research Organization, "Earth Observation Satellites," www.isro.gov.in

is today a tried and tested rocket and is considered the workhorse of the ISRO. The PSLV, a third generation launch vehicle, is a four-stage rocket with alternate solid and liquid propulsion systems. The rocket can carry a satellite payload of up to 1,600 kg to sun-synchronous orbit and 1,050 kg satellites in geosynchronous transfer orbit. The PSLV launch vehicle has been modified several times depending on the scale of the mission, either for improving the payload carrying capacity or the overall thrust and efficiency aspects.[7] The PSLV completed close to 50 missions until May 2019. It also launched India's two most prestigious missions – Chandrayaan-1 in 2008 and Mars Orbiter mission in 2013 – to the Moon and Mars respectively.

India's opposition to the militarization of outer space

At the same time, India was also an active player in space policy debates globally. It opposed the militarization of outer space and maintained that space must be used for peaceful uses alone. From early on, India articulated this position within international platforms such as the United Nations. As one Indian official put it,

> Outer space was a new field and there were no vested interests to prevent the international community from embarking upon a regime of co-operation than conflict. The problems of outer space were fortunately not those of modifying an existing regime but of fashioning a new pattern of international behavior.[8]

Prime Minister Indira Gandhi took the floor at the UN in 1968 to argue the same.[9] India continued this policy emphasis in the subsequent decades until the beginning of the 2000s. In fact, India was noted for its stringent criticism of the US 'Star Wars' programs and the anti-satellites tests conducted by the US and the Soviet Union in the 1970s and 1980s. In the mid-1980s, India's Ambassador at the Conference on Disarmament in Geneva, Muchkund Dubey called for "negotiations to prevent an arms race in outer space."[10] India furthered this reputation with Prime Minister Rajiv

7. A. Lele, "PSLV-C29: Demonstrating India's Growing Space Capabilities," *IDSA Comment*, Institute for Defense Studies and Analyses, December 22, 2015, https://idsa.in.
8. C. Jayaraj, Secretary General, Indian Society of International Law, "India's Space Policy and Institutions," *Proceedings, United Nations/Republic of Korea Workshop on Space Law, United Nations Treaties on Outer Space: Actions at the National Level*, Nez York: United Nations, 2004, www.oosa.unvienna.org.
9. *Ibid*.
10. "India Opposes SDI," *Strategic Digest*, Vol. 15, No. 10, October 1985, p. 1304, cited in: A. Tellis, "The Evolution of US-Indian Ties: Missile Defense in An Emerging Strategic Relationship," *International Security*, Vol. 30, No. 4, 2006, p. 114.

Gandhi sponsoring in 1985 a declaration of six non-aligned countries opposing an arms race in outer space and nuclear testing.[11]

Much of India's position in these earlier debates was based on concerns such as morality and sovereignty. As one of India's leading strategic analysts, C. Raja Mohan, put it, "in the debates on outer space in the 1970s and 1980s, India tended to focus on strengthening state sovereignty. Like most other developing countries, India sought to limit the use of direct broadcast satellites based in outer space."[12] During this time, India also came up with concepts like non-discriminatory, comprehensive and universal disarmament, including in outer space, a reflection of the principled and morality-based approach, which dominated the Indian security thinking.

But this policy approach driven by sovereignty and morality concerns had to change, as the circumstances in India's own neighborhood began to change with greater security dynamism coming into play. China's strategic and economic penetration in India's backyard in South Asia clearly upped the ante among policymakers in New Delhi. The growing and strengthened partnership between China and Pakistan in the military sphere, including the transfer of nuclear and missile capabilities, became a particularly big concern because of its ability to alter the military balance in southern Asia. India thus began to, for the first time in the mid-1990s, approach missile defense in a positive manner, exploring the possibility of developing its own missile defense system to be secure from the growing threats in the region.[13] One of the most visible and very first instances of India's changing tack was its position on missile defense and military space capabilities, including anti-satellite weapons.[14] In other words, from being a vehement critic of the US Strategic Defense Initiative (a space-based anti-missile defense program) and the anti-satellite tests conducted by the US and USSR in the 1970s and 1980s to conducting its own anti-satellite (ASAT) test in 2019, India's approach has become a lot more calibrated, one that is cognizant of the changing and dynamic security environment, including in outer space. This has called for greater Indian understanding of other

11. R. P. Rajagopalan, "India's Changing Policy on Space Militarization: The Impact of China's ASAT Test," *India Review*, November 2011, pp. 354-378, www.tandfonline.com; R. P. Rajagopalan and A. John, "A New Frontier: Boosting India's Military Presence in Outer Space," *Occasional Paper No. 50*, Observer Research Foundation, January 2014, www.orfonline.org.

12. C. R. Mohan, "Rising India: Partner in Shaping the Global Commons?" *The Washington Quarterly*, July 2010.

13. R. P. Rajagopalan, "Strategic Implications of India's Ballistic Missile Defense," *Working Paper*, Federation of American Scientists, August 2017, https://fas.org.

14. For a detailed perspective on the Indian approaches to missile defense, see A. Tellis, "The Evolution of US-Indian Ties: Missile Defense in an Emerging Strategic Relationship," *International Security*, Vol. 30, No. 4, Spring 2006, pp. 113-151.

countries like the US, which have pursued such technologies, but also a willingness to embrace technologies that may not entirely fall within what India traditionally campaigned for in its opposition to the militarization of outer space.

Maturing of the Indian Space Program

India's Mars and Moon missions

India's space program has contributed enormously to the country's growth and development agenda through its roster of satellites with utilities spread across agriculture, health, education, commerce, communication and disaster warning and mitigation. ISRO's contribution to these sectors over the last five decades is remarkable. But, as with any space program, as it gained more sophisticated capabilities, ISRO's ambitions have also grown. India has now also embarked upon pure space exploration programs to better understand outer space and other celestial bodies, and ISRO had developed its space technologies accordingly. The first Mars and Moon missions were technology demonstrators that India was now capable of undertaking these kinds of missions.

ISRO launched its first Moon mission, Chandrayaan 1 ("Moon craft" in Sanskrit), in October 2008 by sending an orbiter around the Moon. This was a major feat for India, undertaken so far only by a couple of countries. In addition to the renewed interest around the world in lunar exploration, the Indian scientific community believed that a mission to the Moon could bring back greater thrust on basic science and engineering as well as challenge ISRO itself to go beyond the boundaries of the geostationary orbital missions.[15] One of the most significant scientific contributions of Chandrayaan 1 was the discovery and confirmation of water molecules on the Moon, where the mission used the Mineralogy Mapper instrument developed by NASA. Carrying a total of 11 scientific payloads including from the US, UK, Germany, Sweden and Bulgaria, Chandrayaan 1 remained operational until August 2009.[16] It performed more than 3,400 orbits around the Moon and gathered 70,000 images of the Moon, and this will go to strengthen humanity's understanding of the Moon. Chandrayaan 1 also conducted chemical and mineralogy mapping and high-resolution remote sensing of the Moon in visible, near infrared (NIR), low energy X-rays and high-energy X-ray regions. The chemical and mineralogy mapping sought to

15. Indian Space Research Organization, "Chandrayaan: India's First Lunar Exploration Mission," www.isro.gov.in.
16. Indian Space Research Organization, "Chandrayaan-1," October 22, 2008, www.isro.gov.in.

understand the distribution of elements such as magnesium, aluminum, silicon, calcium, iron and titanium as well as high atomic number elements such as radon, uranium and thorium with high spatial resolution.[17] Other important goals included testing the deep space tracking network systems, the parameters for travel into deep space as well as the successful functioning of orbit-raising manoeuvres of the spacecraft from 22,000 km to 384,000 km.

But a successor mission, Chandrayaan 2, attempted in September 2019, faced a setback. This mission was to be a major feat for ISRO because this was India's first attempt at landing on a non-terrestrial surface. The primary mission of Chandrayaan 2 was to soft-land on the south polar region of the Moon. Choosing an unmapped region for its first attempt at soft landing was indeed a demonstration of the confident leadership within the ISRO, but the setback is more an indicator of the difficulty of such missions than of any fundamental problems with the ISRO's technology or organization itself.

However, the successful Chandrayaan 1 mission in 2008 was a big boost for the ISRO scientific community, pushing India to pursue more ambitious and challenging missions such as the mission to Mars. Mangalyaan ("Mars craft" in Sanskrit), was India's first inter-planetary mission. Its successful completion made India the first Asian country to achieve this feat in 2013 and the first nation to reach the planet Mars in its first attempt. Though there were some unflattering comparison between India's Mangalyaan and the US' MAVEN mission, it should be noted that the mission goals were quite different.[18] For India, this being the first attempt, it was more of a technology demonstration of the country's capacity to undertake such missions. In addition, ISRO also sought a mission that was complimentary to the missions done by other countries, thus contributing to the global scientific understanding of the planetary system.

Therefore, even though missions such as Mangalyaan and Chandrayaan were not part of the original ISRO vision for its space program (for example, as outlined in the Sarabhai profile), these demonstrate the changed Indian priorities in a number of ways. First, the development of India's technological abilities through such high profile missions can themselves be an important driver for enthusing India's scientific community. Second, such missions are also a reflection of the increasing competition between

17. For details of the mission experiments and payloads, see Indian Space Research Organization, "Chandrayaan: India's First Lunar Exploration Mission," www.isro.gov.in.

18. For a comparison of the costs and payload, see R. P. Rajagopalan and V. S. Reddy, "India's Evolving Space Program and Policy: A Story of Rising Ambitions," in: H. V. Pant, *India's Evolving National Security Agenda: Modi and Beyond*, New Delhi/Seattle: Konark Publishers Private Limited, 2019, p. 75.

India and China and the general space race that is beginning to gather momentum. The fact that India was attempting its Mars mission before China succeeded in its Mars mission was quite possibly a consideration for Indian officials. Indeed, China had attempted a Mars orbiter mission back in 2011 by piggybacking on a Russian Mars spacecraft, but the mission was not successful.

But a mission such as Mangalyaan also drew many criticisms suggesting that India had far too many developmental challenges (including the fact that around 500 million of its population were living below the poverty line) and that it was not appropriate for India to waste its resources on such prestige-driven missions. India is not new to such criticisms. The reality is that India's missions have been extremely cost-effective. Moreover, these demonstrations strengthen ISRO's visibility as a space player, and create positive effects domestically in generating interest on outer space and science and technology more generally. The security environment around India has also been a compelling driver for India to undertake such missions. India does not enjoy a benign neighborhood and the demonstration of these capabilities can also add to the deterrent mix.[19]

Improved rocket technology

All of these ambitious missions are supported by India's improved rocketry capabilities. After several ups and downs in the earlier stages with its SLVs and the ASLVs, ISRO has made remarkable progress in rocket technology. The launch record achieved through ISRO's trusted workhorse, the PSLV is commendable. The PSLV's successor, the Geosynchronous Satellite Launch Vehicle (GSLV), is also maturing and becoming more reliable as a heavy lift rocket. The fact is that GSLV will be critical for India's future missions such as new editions of the Chandrayaan mission, as well as crewed space missions, which are also in the pipeline.[20] Geosynchronous Satellite Launch Vehicle Mark II (GSLV Mk II) is the largest of ISRO's launch vehicles developed by India. The fourth generation launch vehicle is a three-stage rocket with four additional liquid strap-on booster rockets. The GSLV Mk II has an indigenously developed cryogenic upper stage on its third stage. GSLV is important for strengthening India's ability to launch heavy satellites that are in the weight range of 2000 to 25000 kg. India has been relying on the French Arianespace for launching its heavy payloads, but its success with

19. For more details on the push factors for India's Mars mission, see R. P. Rajagopalan, "India's Race to Mars Goes Way beyond Science," *The Wall Street Journal*, 5 November 2013, https://blogs.wsj.com.

20. A. Lele, "ISRO Cannot Afford Failures," *IDSA Comment*, Institute for Defense Studies and Analyses, December 28, 2010, https://idsa.in.

the GSLV should reduce this dependence. India plans to develop GSLVs that are capable to launching 4,000 kg in the near timeframe. These are still moderate capabilities when compared with other heavy rockets in the hands of the more advanced space players.

While the GSLVs do use some components borrowed from the PSLV, the upper stage cryogenic engine is a complex technology that was until now available only with a few countries such as the US, Russia and France. Cryogenic engines use liquefied Oxygen and Hydrogen, which provide more thrust for every kilogram of fuel consumed, thus improving the payload capacity and efficiency of the GSLV.[21] India attempted in 1992 to acquire this technology from the Soviet Union but was unsuccessful because the US used Missile Technology Control Regime (MTCR) regulations to pressure Moscow and deny the technology to New Delhi. The MTCR came into play because the US argued that India would be using cryogenic technology to improve the performance of its ballistic missiles. As a result, India had to develop cryogenic rocket engine technology indigenously, but its attempt has not been smooth. The GSLV Mk II, using such engines, had five failures and two successful missions between 2001 and 2010. After a gap of four years, in 2014, the GSLV Mk II had a successful mission using the indigenous cryogenic stage, but ISRO is still doing only one launch per year, rather than the expected rate of two to three per year.

In June 2017, GSLV Mk III, a new version of the GSLV launcher, made its maiden successful launch.[22] If the GSLV Mk III continues to be successful, there is a big commercial market for that particular class of satellite launchers that India can tap into. Given the increasing demands in the broadband and broadcasting sectors, this market is likely to generate considerable revenue in the coming years. ISRO's commercial wing, the Antrix Corporation, has its eyes set on exploiting this market but, as the ISRO officials have noted, there will need to be several hat-tricks moments for India before this can happen.[23]

21. For details on the technology and the history of India's efforts to acquire this technology, see the section on cryogenic engine and GSLV program in R. P. Rajagopalan and V. S. Reddy, "India's Evolving Space Program and Policy: A Story of Rising Ambitions," in: H. V. Pant (ed.), *op. cit.*, pp. 77-80.

22. For a comparison of the global gestation periods in developing cryogenic engines for heavy launch rockets, see A. Lele and P. Bhardwaj, "Heavy Satellite Launch Vehicles: An Assessment," *IDSA Issue Brief*, Institute for Defense Studies and Analyses, February 19, 2014, https://idsa.in.

23. R. Sengupta, "India's Space Business is Ready for Lift-off," *LiveMint*, June 15, 2017, www.livemint.com.

India's manned spaceflight program (Gaganyaan)

The next major mission for ISRO is India's first crewed space mission, Gaganyaan ("sky vehicle" in Sanskrit), to be undertaken by 2022. During his Independence Day speech on August 15, 2018, Prime Minister Narendra Modi stated that as India celebrates the 75th year of its independence, it will have an Indian astronaut aboard Gaganyaan, "unfurling the tricolor in space."[24] A successful Gaganyaan mission will make India the fourth country to send a human to space. The only Indian astronaut so far is Rakesh Sharma, an Indian Air Force pilot, who flew on a Soyuz T-11 for almost eight days in 1984. The ISRO leadership did not consider human space missions to be a priority because they did not see any significant technological spin-offs through such missions.[25]

Detailing the Gaganyaan plans throughout 2019, ISRO Chairman Dr. Sivan said that it would be a completely indigenous one and would result in the creation of additional jobs in the coming years. The remarks were also aimed at countering some of the possible criticism that such missions were all prestige missions with little economic benefit. He added that ISRO would work with scientific institutions like the Institute of Aerospace Medicine in Bengaluru and India's space industry, including start-ups. Other senior officials within the Department of Space added that there could be foreign collaboration as well, including with Russia and France.

While human space mission was not until now a top priority, ISRO has been working on various aspects of it in any case.[26] Financial allocation has been a major factor as to why ISRO had not put this on their immediate calendar. ISRO is yet to announce the cost estimate of the mission, but reports citing ISRO sources say that it will be around 100-120 billion rupees, which is approximately USD 1.4-1.7 billion.[27] The previous UPA government of Prime Minister Manmohan Singh had allocated INR 1.45 billion rupees (USD 20.68 million) for pre-launch work.[28] Back in December 2013, the Vikram Sarabhai Space Centre (VSSC) Director S. Ramakrishnan stated

24. "Full text of PM Modi's Independence Day speech," *Indian Express*, August 16, 2018, https://indianexpress.com.
25. "'Satellites Are Our Priority Now, Not Human Space Flight'," Ajay Sukumaran Interviews A. S. Kiran Kumar, *Outlook*, July 13, 2017, www.outlookindia.com.
26. For status and updates on ISRO's Gaganyaan mission including the first meeting of the Gaganyaan National Advisory Council, see Indian Space Research Organization, "First Meeting of Gaganyaan National Advisory Council," June 8, 2019, www.isro.gov.in.
27. C. Kumar, "India to Launch First Manned Space Mission by 2022: PM Modi," *Times of India*, August 15, 2018, https://timesofindia.indiatimes.com.
28. *Ibid*.

that, "it would take 10 years for India to undertake human space flight."[29] ISRO has already developed some of the critical technologies, using around INR 600 million rupees from its internal R&D budget.[30] But now that the political leadership has made this a priority, there is hope for a steady flow of financial assistance.

As of now, the GSLV Mk III has been used to test an early model of the crew module in what was called the Crew module Atmospheric Re-entry (CARE) test (December 2014), to authenticate the performance of parachute-based deceleration system and to understand the re-entry aerothermodynamics. But Indian leaders have set a very ambitious target for the manned mission: ISRO has slightly more than two years to accomplish this major task. It is, however, important for various reasons. First and foremost, as the Indian space program evolves, this is the next logical step. While one may not see an immediate and direct economic linkage, in the longer-term, such missions are likely to bear fruit, especially in terms of the spin-off technological benefits derived from the mission. Second, the mission will add great weightage and visibility to the Indian space program. Just like India's Moon and Mars missions have highlighted India's space profile, Gaganyaan is also likely to highlight the growing sophistication of India's space program, an aspect that India should not shy away from emphasizing as the space security competition picks up momentum.

A growing private sector space industry

Another way in which the Indian space program is maturing is demonstrated by the growing private sector space industry in the country. This is of course not comparable to the kind of private sector participation and initiatives that can be found in the US or even in China. Nevertheless, there are now at least a dozen private sector space start-up initiatives, especially in the southern Indian cities of Bangalore and Hyderabad. There are at least four reasons for the growth of such private sector interest. One is the generally more favorable ecosystem for the growth of private sector start-ups. Though the Indian economy remains significantly state-managed, the loosening of government regulations and restrictions since the economic liberalization in the 1990s has encouraged the Indian private sector to develop private business initiatives. This has had an impact on India's space sector also. The second reason is ISRO's own initiatives in building up a cadre of young space entrepreneurs through its training activities, especially the Indian Institute

29. "ISRO Gearing up for Space Capsule Recovery Experiment," *The Hindu*, December 21, 2013, www.thehindu.com.
30. C. Kumar, "PM Vows to Put Indians in Space by 2022, ISRO Begins the Long Trek," August 15, 2018, https://timesofindia.indiatimes.com.

of Space Science and Technology (IIST) based in the southern state of Kerala. Though it was not designed to develop space entrepreneurs as such, the IIST did end up creating a large cadre of young space scientists and technologists who sought opportunities beyond India's government space sector. They have formed the backbone of the new Indian private space sector. A third factor is the demonstration effect of private sector space ventures in other parts of the world, especially the United States. That has excited these new entrepreneurs in India as much as they have elsewhere in the world. A final reason is the return of a good number of Indian science and technology graduates from abroad, who were keen on employing their talents and experiences to develop a private Indian space sector.

The consequence of all this has been a significant growth in India's private sector space ventures. Though the Indian private sector has had a role in the Indian space program even earlier, this was limited to large engineering corporations that were sub-contracted to build specific components that were designed by ISRO. Large Indian corporations like Larsen & Toubro (L&T), Godrej and Walchandnagar received contracts from ISRO to fabricate specific parts of India's rocket engines. For example, L&T has been a major contributor to ISRO's missions by manufacturing motor casings, critical subsystems and 32M Deep Space Network Antennas for tracking systems for all of ISRO's space missions, including India's Chandrayaan and Mangalyaan.[31] Similarly, Walchandnagar Industries is reported to have "secured an order worth INR 77.20 crore from Vikram Sarabhai Space Centre of ISRO (Thiruvananthapuram) (...) for manufacture and supply of head, middle and nozzle end segments (total 30 numbers) for the GSLV M KIII launch vehicle."[32]

More recently, the newly emergent smaller space start-ups have gone beyond the traditional model to design their own systems. Some have done so under contract to ISRO. For example, Alpha Design Technologies, a Bangalore-based firm has been contracted to build a heavy-duty satellite for ISRO's indigenous NAVIC navigation system.[33] But others have stuck out on their own, building satellites independently of ISRO as well as developing other technologies on their own. Especially given its internal capacity deficit, ISRO is likely to give these private ventures greater attention and support. It has already begun to reach out to the small and medium-size enterprises

31. Larsen & Toubro, "Space," www.larsentoubro.com.
32. "ISRO Order May Fuel Walchandnagar Ind," *Hindu Business Line*, September 13, 2019, www.thehindubusinessline.com.
33. "ISRO Outsources Satellite Manufacture," PTI, Hindu Business Line, January 15, 2018, www.thehindubusinessline.com.

to contribute to its own growth story.[34] ISRO's establishment of New Space Industries Limited (NSIL) in March 2019 could go a long way in finding a mutually acceptable pathway to work together.[35]

Despite the maturation of India's space program, many countries continue to be critical that India, a developing country, is developing a space program, including missions to Moon and Mars. They see it as a waste of precious resources. However, the reality is that India's space budget is still a small percentage of its GDP and the overall government spending. ISRO's budget is just INR 12,000 crores (USD 1.8 billion), which is half a per cent of the total government expenditure. While it is true that some of these big missions do not have immediate and direct economic impacts, such missions highlight both the overall profile of India as a rising power and its space program as credible and cost-effective. This attraction of being a cost-effective space power incentivizes many emerging space players to seek India as a possible destination for launching their satellites, thus adding to the overall economic viability of the program. In addition, these missions are required in order for India to secure a seat at the high table during discussions of global governance debates. Last but not the least, as India's space program evolves, these are natural and logical steps that no space power can ignore, especially at a time when competition is picking up in the Indo-Pacific. India cannot afford to sit on the margins. In fact, this growing competition in the Indo-Pacific is a critical factor.

34. "ISRO Invites Small Industries to Manufacture Rocket Parts," *The Hindu*, February 27, 2018, www.thehindu.com; M. Ramesh, "ISRO 'Ready to Support' Private Rocket-Launching Companies," *The Hindu Business Line*, September 4, 2019, www.thehindubusinessline.com.
35. R. P. Rajagopalan, "India's Space Program: The Commercial Domain," *The Diplomat*, May 10, 2019, https://thediplomat.com.

Space and National Security

Shifts in India's position on the non-militarization of space

India's traditional approach to outer space, one that emphasized peaceful purposes and non-militarization of space, began to change in the early 2000s. This move was driven by the evolving security threats that India faced, especially in relation with Pakistan and China. This has compelled New Delhi to make some important changes to both its policy and program. While the official policy itself has not changed, India is beginning to have a much more determined approach to how it wants to protect its assets in outer space as well as its ground infrastructure and the services linked to space. This has raised questions on whether India should develop certain counter-space capabilities to undertake such tasks.

This change itself has been part of a larger policy shift in how India has approached the global security norms and regulations. During the same time period, India has also been taking steps to align itself with the non-proliferation order and to become part of the emerging non-proliferation order. Historically, India has had a challenging relationship with the international non-proliferation regimes, including with the export control regimes that are meant to serve these objectives. But over the last decade, India's relationship has undergone some major changes. Given the growing technological profile of India, there has been an effort on the part of the global non-proliferation community to bring India within the tent. At the same time, India too has taken steps to integrate with the non-proliferation architecture because it wants to actively contribute to the global non-proliferation cause and wants to be seen as part of the solution rather than the problem, as was the case for several decades earlier. In other words, India has shown itself to be keen to play a bigger role in shaping the global norms and agenda rather than being a silent spectator.

Thus, one of the big shifts evident in the last decade is the development of India's military space capabilities and the establishment of the institutional architecture that supports the new functions and roles for space in India's national security calculations. The fact that India's official position has not changed may be an issue, but from a domestic national security perspective, it is more important that India is taking the necessary steps on

the ground to address the new and emerging challenges.[36] The changing security dynamics in its own neighborhood as well as in the broader global arena has pushed India to remove some of its earlier inhibitions. In consequence, the military characteristics of its space program are becoming more evident. India is also moving away from its traditional, comfortable position of non-weaponisation of space to a more nuanced approach to its national space policy as well as its position in global governance debates.

These policy shifts have indeed not been easy. India has been reluctant to alter its traditional opposition of non-weaponisation because this was a policy that it has had for decades. India did shift slightly in May 2001 when it moderated its opposition to ballistic missile defenses when the US withdrew from the ABM Treaty. That was seen as a dramatic change but one that was driven by a couple of different imperatives. One was India's desire to build friendlier relations with the Bush administration in the aftermath of India's nuclear weaponisation (in 1998). The second was India's own security concerns because of Pakistan's acquisition of ballistic missiles. This led India to pursue ballistic missile defenses, making India much more willing to consider the utility of such weapon systems. This latter factor -- keeping pace with the expansion of Pakistan's ballistic missile capabilities -- has become stronger over the years. In addition, China's first successful anti-satellite (ASAT) test in January 2007 added a new wrinkle because it suddenly made India's space-based assets vulnerable. India thus had to consider developing its own ASAT capability, at least as a deterrent to anybody else using ASATs against Indian assets in space.

Keeping pace with China's space programs

Another significant reason for the shift in Indian policy is the growing security concerns that India feels as a consequence of the developments in the Indo-Pacific region, particularly the rise of China. China's efforts to compete with the United States both by developing a robust civilian space program as well as a military space program have had cascading effect on India's security. Though China's civilian space program is older and more mature than India's, China's achievement in space provided an incentive for India to try to keep pace. Thus, though India originally focused on building space assets that would provide direct developmental benefits – for example, by building telecommunications and remote sensing satellites that would help both in providing better

36. Even though India is developing certain military space capabilities in response to the changing space security environment, New Delhi has not changed its official policy of non-weaponisation. But some countries see this as a problem because some of the recent actions are in contradiction to their official policy positions.

communication facilities and direct assistance to India's farmers – India has increasingly shifted at least a part of its focus towards space exploration and other high-profile missions that do not have as clear a developmental purpose as earlier. This includes, for example, India's Mars and lunar exploratory missions as well as upcoming projects such as the manned space mission. India has been fairly successful in these efforts, but the increasing competition with China can be expected to provide further impetus to such programs and to accelerate the pace of this shift in India's focus.

The competition with China also has a security component, again as a consequence of the cascading effect of China's own efforts to match or counter the American military power. China has sought to counter the US, a far stronger adversary, by looking for weak points in the American military machine. Though this has many facets, a significant one relates to space technology. China appears to have realized that the US has an important vulnerability because its military power is dependent on satellite-based communication, intelligence and reconnaissance. China has developed a number of technologies to target this vulnerability, including cyber and electronic warfare means.[37] Even more seriously, China has also built an ASAT weapon, breaking a moratorium that existed since the mid-1980s, as well as technologies to blind and otherwise disrupt satellites and services.[38] While all of these technologies were developed possibly with the US in mind, they clearly have had consequences for India's security too. As stated earlier, China's achievement in space led not only to India's own ASAT program, but also to other elements that enhanced the security component of India's space program.

Growing synergies between space and the Indian military

India began an internal discussion almost a decade back about reorganizing the security aspects of its space program and integrating it more fully with India's military. Beginning with the establishment of an Integrated Space Cell within the Integrated Defense Staff of the Ministry of Defense in 2008, India made steady progress in creating greater synergy between the space and the military programs and between the space requirements of different services of the Indian military. In particular, India established a Defense Space Agency (DSA) in April 2019. The DSA is expected to be the forerunner for a full-fledged aerospace command, which is expected to be established sometime in the near future. In addition, India is also establishing a Defense

37. R. P. Rajagopalan, "China Extends Terrestrial Rivalries into Orbit with New Space Race," *Nikkei Asian Review*, August 23, 2019, https://asia.nikkei.com.
38. R. P. Rajagopalan, "Electronic and Cyber Warfare in Outer Space," *Space Dossier 3*, United Nations Institute for Disarmament Research, May 2019, www.unidir.org.

Space Research Organization (DSRO), which is meant to undertake research and development on the capability mix that is required as per the strategy and policy developed by the DSA.[39] In a first, India conducted a space security table-top war game in late July 2019. This exercise, which was called "IndSpaceEx", involved all the different stakeholders such as the military and the scientific establishment. It is another reflection of the growing synergistic approach between space and the military.[40]

While China has been a big factor in determining the shape and direction of India's space program, there have been other drivers as well. India has increasingly sought to leverage space technology for surveillance to manage the threat from across the Pakistani border, especially that related to terrorists and their bases and infiltration efforts across the India-Pakistan border.[41] India has deployed a number of satellites for such purposes. The Ministry of Home Affairs is also establishing a Space and Technology Cell to monitor border areas to check for intrusion from Pakistan and China. The new cell under the Border Management Division will be manned by officers from ISRO and the Defense Research and Development Organization (DRDO).[42] Pakistan's expanding nuclear weapons program has also been a target, with India developing additional space-based assets for the surveillance of the Pakistani military, specifically of Pakistan's nuclear forces.[43] It is not difficult to surmise that, surrounded by two nuclear power – Pakistan and China - India will also eventually likely develop space-based early warning system. In terms of technological improvement, it will not be extremely difficult, although it would involve some special capability requirements. One important parameter though may be in ISRO's ability to meet the growing demands, which is already an issue.

On a positive note, the competition with China is also leading to greater cooperation between India and a number of space powers in the Indo-Pacific such as Japan, Australia and France, all of whom feel threatened or concerned by China. These partnerships are likely to gather greater momentum given the broader convergence of their strategic interests to maintain an open, stable and secure Indo-Pacific strategic order.

39. R. P. Rajagopalan, "India's Strategy in Space is Changing: Here's Why," *World Economic Forum*, August 14, 2019, www.weforum.org.
40. For details, see R. P. Rajagopalan, "A First: India to Launch First Simulated Space Warfare Exercise," *The Diplomat*, June 12, 2019, https://thediplomat.com.
41. "ISRO to Launch Exclusive Satellite to Help MHA in Securing Pak, Bangladesh Borders," PTI, *The Economic Times*, January 17, 2019, https://m.economictimes.com.
42. D. Singh, "MHA Setting up Space & Tech Cell to Track Borders," *The Economic Times*, November 27, 2018, https://economictimes.indiatimes.com.
43. C. Clary and V. Narang, "India's Counterforce Temptations: Strategic Dilemmas, Doctrine, and Capabilities," *International Security*, Vol. 43 No. 3, Winter 2018-2019, pp. 7-52.

Conclusion

Over the last several decades, India's space program has changed significantly. It has become a comprehensive one that includes not only a robust launch capacity but also a very well rounded scientific and deep space exploratory program. In the last decade, this already robust program has also acquired national security overtones. This is partly driven by India's growing technological capacity. But an important part of the reason for this change is also the growing competition in Asia that is driving the Indian space program in new directions. This last factor, in particular, is only likely to become more important in the coming years.

Outer space is not immune to terrestrial security competition and the lack of sufficient safeguards, international norms and institutions, means that there are few restrictions on this competition. Though there have been international efforts to develop norms to moderate this competition, these have not gone very far. The heightening international tension and great power competition mean that the chances of building additional norms will likely not bear fruit. This is of course no reason to stop trying. But we cannot also be unrealistic in the pursuit of new normative efforts.

In the absence of global governance or multilateral efforts, it is likely that mutual deterrence will remain the sole moderating influence on competition in space, especially in the security realm. But this has its own dangers. Deterrence requires that countries at the very least develop capabilities even if they do not actually deploy them. But the development of these kinds of capabilities carries with it the dangers that they could be deployed. These developments threaten not only countries that are directly in competition, but also others, who may not be part of the competition. The Indian space program, thus, is being carried along not only because of India's developmental needs, but also because of larger international political factors.

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